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THESIS

TRANSONIC AXIAL COMPRESSOR DESIGN CASE STUDY AND PREPARATIONS FOR TESTING

by

William D. Reid

September, 1995

Thesis Advisor: Raymond P. Shreeve

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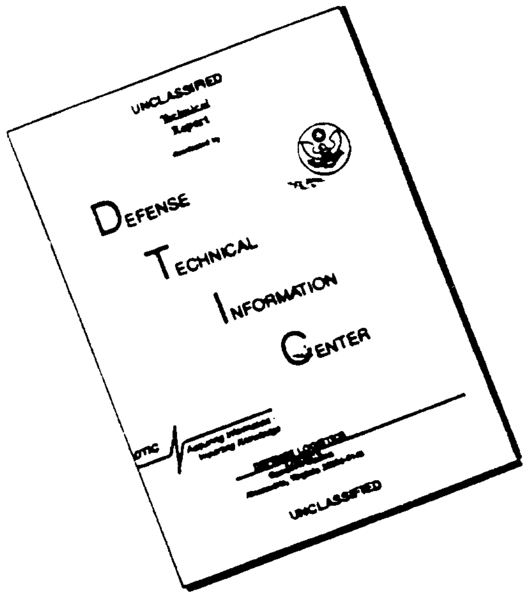

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A case study of the design of the new transonic stage was initiated. This consisted of a review of the procedure used in the design, as well as a design comparison. The comparison examined the differences between the blades designed for the new stage, which was primarily accomplished using a full, three-dimensional, Computational Fluid Dynamics code, and blades designed using two-dimensional streamline curvature methods. The axi-symmetric through-flow code, used in the design case study was modified to run on workstations at the Naval Postgraduate School, Department of Aeronautics and Astronautics, providing students and faculty with a design tool for single or multiple stage axial flow compressors.

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TRANSONIC AXIAL COMPRESSOR DESIGN CASE STUDY AND PREPARATIONS FOR TESTING

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Submitted in partial fulfillment
of the requirements for the degree of

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LIST OF SYMBOLS

Ψ	Specific Head Rise Parameter
C_p	Specific Heat at Constant Pressure
T_{01}	Inlet Total Temperature
PR	Pressure Ratio, Total-to-Total
γ	Ratio of Specific Heats
U_t	Rotor Wheel Speed at Tip

I. INTRODUCTION

The Naval Postgraduate School (NPS) transonic axial compressor design was completed by Dr. M.H. Vavra in July of 1968. All of the calculations and drawings required for the complete aerodynamic and mechanical design were done by Dr. Vavra alone, by hand. From 1968 until the mid 1980's the compressor served well as a test vehicle for the development of innovative flow measurement instrumentation as well as a means for graduate students to gain experience in the operation, test, and analysis of high speed compressors [Ref. 1-5]. The initial stage design was unique but no real technology advance was attained. This was due to two design inaccuracies, discovered after some period of testing. In addition to an incorrect assumption of constant through-flow velocity, an error was made in the calculations associated with the rotor blade setting angle, and this was subsequently built into the blading [Ref. 6]. Consideration was given to twisting the fabricated blades to correspond with the shape intended in the design. This was not attempted since the design itself had resulted from an inaccurate through-flow prediction. Following the completion of a study by Neuhoff [Ref. 7], to measure rotor losses, and to separately identify shock and viscous components, the compressor was not operated again until the present study was initiated.

A transonic axial compressor stage designed specifically for the existing NPS transonic test rig, shown in Figure 1, was completed at NASA Lewis in 1994, by Nelson L. Sanger [Ref. 8]. This new design was sought to perform the functions originally intended for the Vavra design, namely, to serve as a test vehicle for instructional purposes, and to provide a tool for meaningful research. However, the timing of the project, after a period of years in which advanced Computational Fluid Dynamics (CFD) methods for turbomachinery had evolved, provided a unique opportunity. The design would provide a test of a wholly CFD design approach. The experimental evaluation would provide both a validation of the design approach, and an experimental test case for CFD analysis codes. The manufactured blading is shown in Figure 2.

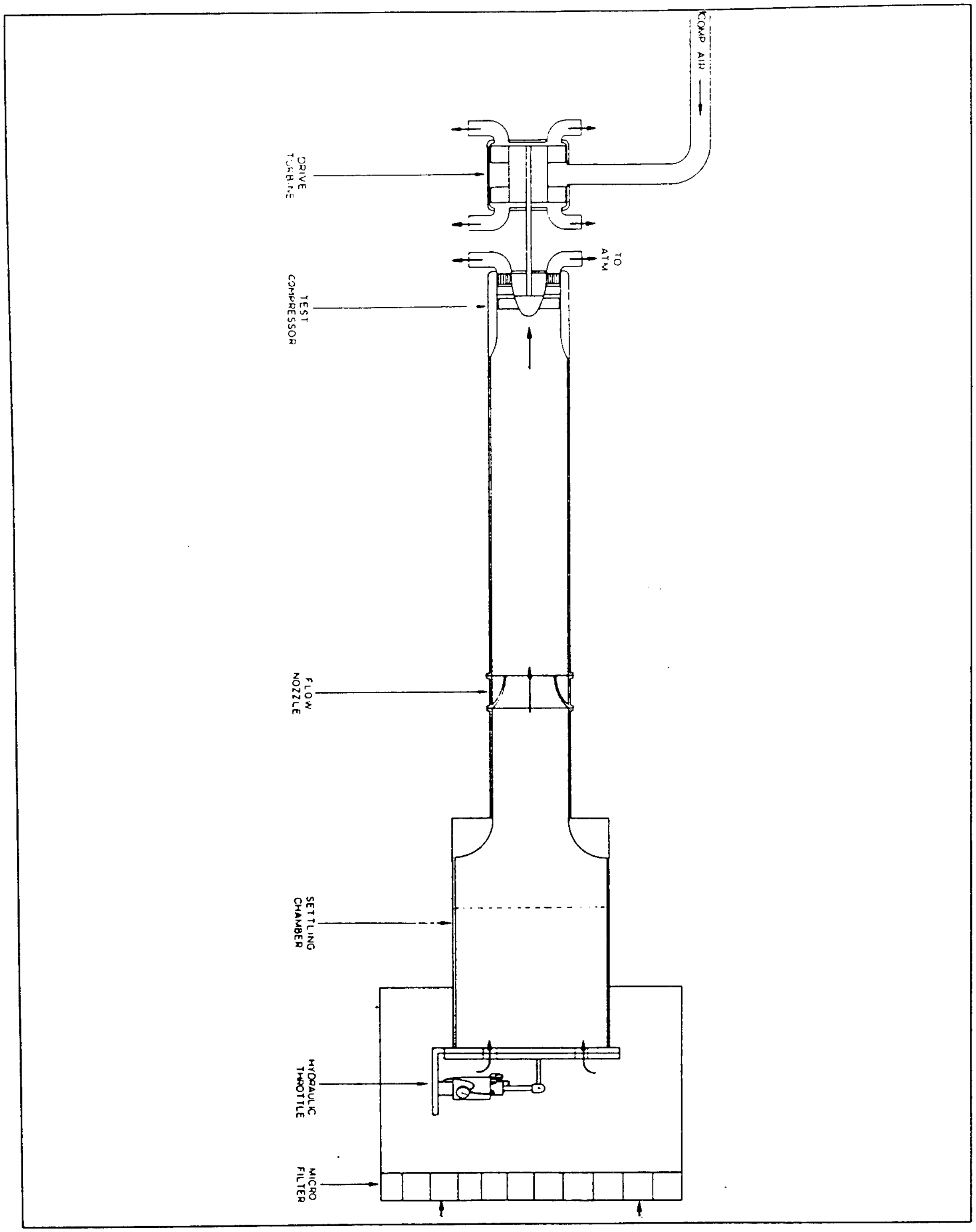

Figure 1. Transonic Compressor Test Rig.

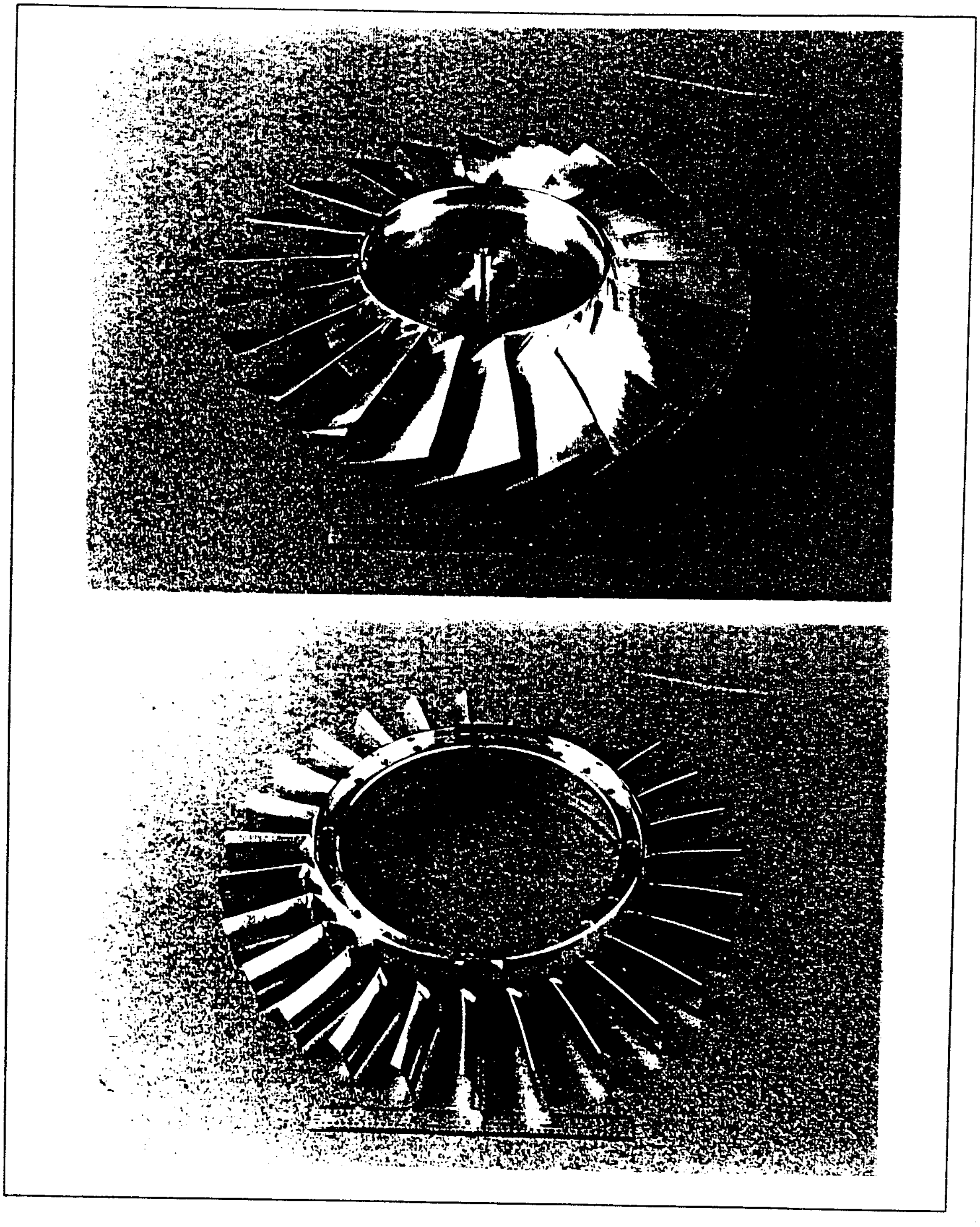

Figure 2. Manufactured Blading; Rotor (Top), Stator (Bottom).

This report is intended to document the effort to bring the NPS transonic compressor test rig back on line, in order to evaluate the newly designed axial stage, and to review, for the record, the procedure used in the stage design. The report has two main sections. The first section contains a review of the process used in the design of the new stage. This section also contains a comparison of the final blade design, resulting from CFD analysis, with a blade design using conventional streamline curvature and axisymmetric through-flow calculations. The second section is an account of the process that was conducted to return the test rig to working order. Appendix A contains a description of, AXIDES, a 2-D blade design code, written by Jim Crouse [Ref. 9], which was used in the preliminary design and in the production of final fabrication coordinates of the new stage. This code has been modified for use at the NPS, Department of Aeronautics and Astronautics, as a tool for advanced axial compressor design. Appendix C contains information regarding the test rig disassembly and reassembly, and the operating procedure.

II. NEW STAGE DESIGN

A. PROCEDURE

1. Design Intent

The object of the design was to produce a state-of-the-art transonic compressor stage, representative of a typical inlet stage, or fan stage. At the time the design was being contemplated, the use of CFD codes as analysis tools was increasing. However there was little work done using these codes for design. Given that the stage was to be used for research and was not intended as an actual aircraft component, the decision was made to use CFD as the principle tool in the aerodynamic design. Additional computer codes were used in the design including the AXIDES code, however these codes were used mainly in supporting roles. The complete package, including the design, testing and measurement of the stage constitutes, in the words of the designer, "the ultimate CFD validation experiment".

2. Preliminary Calculations

Although the design was intended to be derived from state-of-the-art technology, the decision to utilize the existing NPS Turbopropulsion Laboratory (TPL) transonic compressor test rig imposed several constraints that were unavoidable. The decision to use the existing test rig mechanical design was economic in nature. Retooling the rig to produce a desired flow path was determined to be unjustified in light of the cost, and effect on the final design. The constraints imposed on the design included a constant blade tip diameter dictated by the existing compressor shroud, a pre-determined blade chord set by restrictions in the flow path and the need to provide clearance for probe measurements. A further requirement was that the stator discharge angle be axial in order to accommodate the unique torque measuring system (see Chapter III, Section C2). An additional constraint of significant importance was the limitation that the turbine drive unit was capable of providing a maximum of 450 to 470 horsepower.

Within the confines of the physical constraints imposed by the existing compressor rig, the designer conducted a preliminary analysis of desired design parameters with the goal of producing a stage that achieved,

> " as high a loading and specific weight flow as was practical, while keeping rotor tip Mach number at a moderate level. "
>
> Sanger '94

Using the specific head rise parameter,

$$\Psi = C_p\, T_{01}\, (\, PR^{(\gamma-1/\gamma)} - 1) / U_t^2$$

a parametric study was performed. The specific head rise was calculated over a range of tip speeds, and pressure ratios, using as a reference several previous designs, including the original Vavra design and the well known NASA Rotor 67. To produce a design that was state-of-the-art, the initial selection of design parameters was fairly optimistic. Subsequent calculations of the horsepower and inlet ramp angle required to support this selection of design parameters revealed that they were in fact too optimistic. The power required exceeded that available by nearly 200 hp, and the ramp angle on the spinner hub was calculated to be 42 Deg.

In order to reduce the power required by the stage to that constrained by the existing drive turbine, and lower the inlet ramp angle to a more reasonable figure, several compromises had to be made. Notable compromises were the reductions in specific weight flow and rotor and stage pressure ratio, to alleviate the power imbalance, and a reduction in the axial velocity ratio, to reduce the inlet-to-exit area ratio and therefore the inlet ramp angle. With these corrections, the required input power was reduced to 457 horsepower, and the ramp angle became 28.2 Deg. Selection of additional design parameters such as solidity and diffusion factor was primarily based on the designer's experience with similar machines. The results of the parametric study are shown in Figure 3.

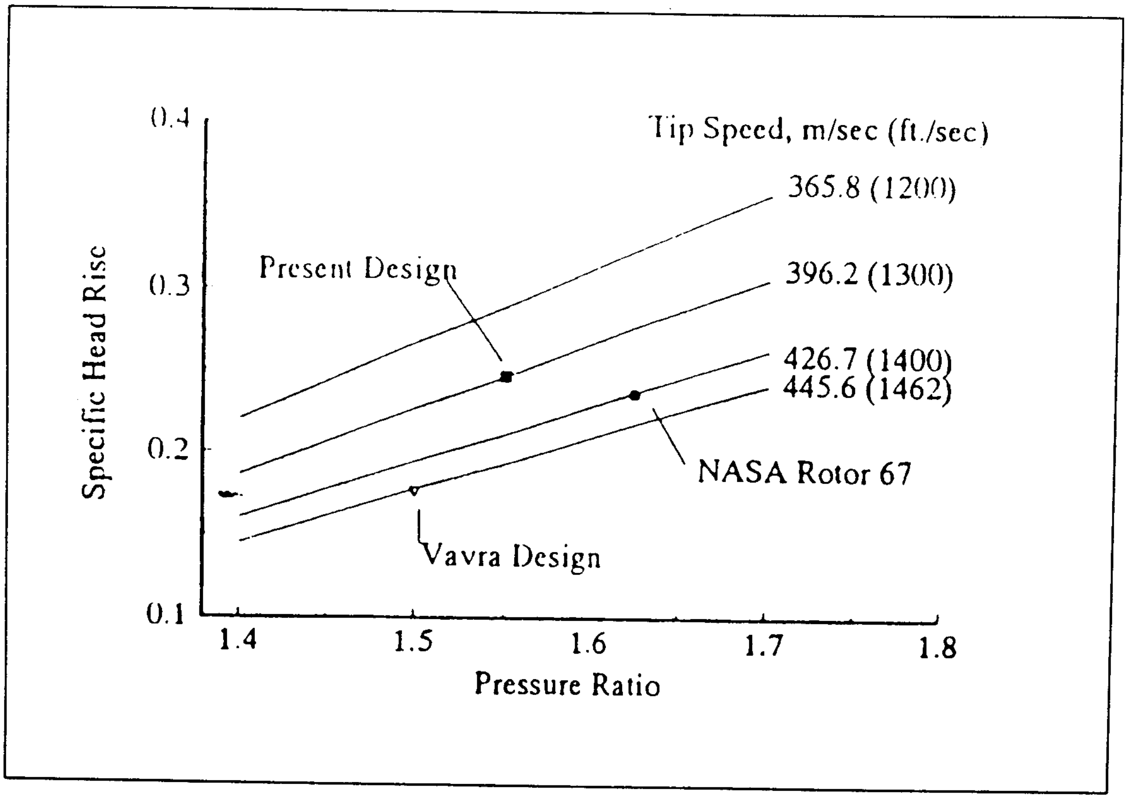

Figure 3. Results of parametric study [from Ref. 8].

3. Final Selection of Preliminary Design Parameters

Prior to this stage in the design the analysis was restricted to one-dimensional methods. To arrive at a detailed description of the flow path, and evaluate the performance of the preliminary design, the designer used the AXIDES code. The reasoning behind using this code was to reveal any obvious deficiencies in the preliminary design and to produce the flow field from which the blading would be derived. The AXIDES code provided the full 2-D radial equilibrium solution, where steady, axisymmetric flow is assumed, and produced distributions of the flow between blade rows at the specified design condition. At this point in the design process the flow-field estimation option of the code was used by setting the parameter OP, of the input data set, to APPROX (see Appendix A). Using this option, no blades are designed or specified. The

code simply estimated blade-edge locations from the stacking line, and produces velocity diagram and performance information based on these approximations.

The information that was specified in the input data set to the AXIDES code was RPM, mass flow rate, stage pressure ratio, inlet total pressure, inlet total temperature, tangential velocity, the flow path of the existing compressor rig, annular station locations, and estimated blockage. Although typically input in the form of loss-correlation tables, the losses across the blading were implicitly defined by entering the total pressure and total temperature distributions at the outlet of the rotor. A discussion of this option of the code can be found in Reference 9, page 12. The total-pressure distribution was essentially constant except for losses at the hub and tip. The total-temperature distribution was also nearly constant, however, higher temperatures were input near the tip to account for increased shock losses along the blades. The values used for estimated blockage and total-pressure and total-temperature distributions at the outlet of the rotor, were based on experience and on the values of successful stages in the same design range. Additional information specified in the input data set were the radial distributions of blade leading and trailing edge radii, chord length, and maximum thickness-to-chord ratio. All of these distributions were based on the designer's experience with transonic rotors. The input used to define the stator attributes were similar. A notable exception was the exit tangential velocity which was zero.

Several iterations through the AXIDES code were conducted, until output distributions of such parameters as diffusion factor and loss appeared reasonable. Modifications to the input data file consisted mainly of variations in pressure ratio and flow path geometry. There was initial concern about the low values of output loss distribution across the rotor. It was decided, however, that if an error in efficiency was to be made, to design for high efficiency and be wrong was better than designing for lower efficiency and be correct.

At the time of this report only a representative example of the final input data set of preliminary design parameters was available. Described as "one of the last" data sets

used during iterations through the AXIDES code, it was a very close approximation of the actual input. This input file was run on the version of the code installed at NPS. The output received was the designer's final preliminary design flow-field and the associated performance parameters. Reference 10 contains this input file in its raw form, and the associated output file. Appendix A gives a description of input and output file structure and parameters.

Once satisfied with the 2-D flow field and performance, the preliminary design parameters were fixed. A list of first cut, and final selection of design parameters is shown in Table 1.

Parameter	Initial Selection	Final Selection
Rotor Pressure Ratio	1.63	1.61
Stage Pressure Ratio	1.60	1.56
Tip Speed	1300 ft/sec	1300 ft/sec
Design Weight Flow	22.21 lb_m /sec	17.09 lb_m /sec
Specific Weight Flow	40 lb_m /sec-ft^2	35 lb_m /sec-ft^2
Specific Head Rise	0.265	0.246
Tip Inlet Relative Mach Number	1.30	1.28
Hub/Tip Radius Ratio	0.40	0.51
Rotor Inlet Ramp Angle	42.0 deg.	28.2 deg.
Power Required	638 HP	457 HP

Table 1. First cut, and final selection of design parameters.

The problem now consisted of blading design to produce the loss distribution, and flow angles, specified in the output of the AXIDES code.

4. Blade Shape Definition

The AXIDES code provided the designer with a picture of the desired flow field, between blade rows, on the meridional plane. The next step was to fit blade shapes to the velocity diagrams to produce this flow. From the conception of the design, it had been decided that CFD would be used to arrive at these blade shapes. The idea was to make an initial "guess" of blade shape, using output from the AXIDES code, run this blade through

the CFD analysis, and check the results. If the output seemed reasonable the design was complete. If not, blade shape modification was required. The designer created initial blade sections essentially by hand, guided by the flow angle distributions produced by the AXIDES code and experience with supersonic flow across blading. Iteration on blade shape, which turned out to be required, was performed using a NASA in-house blade element code, derived from the geometry portion of the AXIDES code.

The procedure used to screen the initial blade sections was modified over the course of the design. Initially, a quasi-three-dimensional code, written by John Denton [Ref. 11], was used. This code was coupled with an integral boundary layer code [Ref. 12], to check the surface boundary layer condition. The Denton code used was an Euler code containing a simple transpiration model to estimate the boundary layer blockage. Together these codes provided the designer with a quick tool for screening the blade shapes.

During the process of designing the blading, the full three-dimensional version of the Denton code (TIP3D), as reported in Denton 1986 [Ref. 13], became available. This code was simply an upgrade in the original Euler code, containing a simple approximation for viscous effects and an empirical equation defining the distribution of shear stress from the wall. Consideration was given to using a code with a more complex and possibly more accurate turbulence-modeling scheme, however, given the iterative nature of the design process, the increase in accuracy was deemed insignificant when compared with the increase in computational execution time.

Using the quasi-3D results as a "base design", the iteration on blade shape was continued in the same manner as previously described, using the updated version of the Denton code. The criteria used for acceptance of the blade included the requirements to minimize shock strength in the tip region and to prevent or delay boundary layer separation. The shock strength was reduced by minimizing the supersonic acceleration of the flow approaching the shock. This was accomplished by making the suction surface at the leading-edge portion of the blade wedge shaped, and curving it after the shock to

provide the required turning. To prevent separation, the attempt was made to control the diffusion towards the trailing edge of the blade. Final-design blade sections, used to generate the now-rotating shape for fabrication, labeled "Sanger Design", are shown in Figure 7, located in section B3 of this Chapter. Because these sections were used for fabrication, they represented elements of the blade on cylindrical planes, parallel to the axis of rotation of the rotor.

5. Fabrication

After all criteria had been met, to within certain acceptable tolerances, the aerodynamic portion of the design was complete. What remained was the mechanical analysis and fabrication of the blading. Historically, the Engineering Design Department at NASA-Lewis had used the same geometry specifications as prescribed in the AXIDES code, to perform their mechanical analysis. Therefore, the final blade parameters were input back into the streamline curvature code using the output option (OP), COORD (see Appendix A). This option created an output file containing blade coordinates for fabrication. A copy of the input file used to produce the final blade fabrication coordinates and the output file containing these coordinates can be found in Reference 10.

B. DESIGN COMPARISON

1. Overview

Streamline curvature methods have been used for the design of many successful machines. Historically, the flow-field between blade rows is calculated using these methods, a blade shape is arrived at, and the flow within the blade row, where any problems are likely to occur, is checked by a more detailed analysis code. The AXIDES code was written with the objective of integrating the design and analysis portions of the overall design process in a more efficient manner. It produces through-flow output that can be directly input into the blade-to-blade analysis codes T-SONIC [Ref. 14], and MERIDL [Ref. 15]. The code also provides input features which allow for corrections in

the blade shape, determined as necessary from the output of these analysis codes, to be easily made. The result is a composite through-flow code, capable of both aerodynamic and blade design, that can be interfaced with two codes that analyze the flow within the blade rows. Currently, the version of the AXIDES code at NPS, is not capable of interfacing with MERIDL. An update to the code should include this feature.

For the reasons mentioned previously, CFD techniques were used throughout for the design and analysis of the new Sanger stage. The AXIDES code was not used as a blade design tool. It was simply used to describe the flow-field which satisfied the requirements dictated by the preliminary design parameters. No blade shapes were input, nor specified by the code, and only velocity diagram and performance information was output. The initial "guess" of the blade shapes was generated by hand. Although iteration on blade definition was performed using a geometry routine extracted from the AXIDES code, the blade sections were stacked based on information produced by the CFD analysis, and not within the aerodynamic iterations of the streamline curvature method. This section contains a comparison between the final Sanger design and a design produced strictly with the use of the AXIDES code; that is, the blading specification and aerodynamic performance output by AXIDES, when used in a design capacity. The motivation for this comparison was two-fold. First, the Crouse 2-D code was to be used for instruction in compressor design at NPS. A comparison with the geometry arrived at using advanced analysis methods, was a useful exercise of the code. Second, no similar comparison was found between a design resulting from relatively simple, and computationally-efficient streamline curvature methods, and the geometry obtained using more detailed flow analysis routines, requiring significant investments in computational time.

2. Method Of Comparison

The performance of the Sanger design was taken from Sanger, 1994 [Ref. 8]. The blade definition parameters and performance distributions, as described previously, were set using the Denton TIP3D code. The AXIDES code was used strictly to provide the

initial flow-field estimate, and produced coordinates of the final blade design in a form that could be conveniently used in the mechanical analysis and the subsequent fabrication process. During the design review, when the picture of the procedure used in the design became clear, there was initial skepticism as to how the final blade design parameters could be input into the AXIDES code, simply to provide the desired form of the blade geometry in the output. The concern was that the program would modify the blade shape as it attempted to converge on a 2-D radial-equilibrium solution. A solution which would obviously be, at the least, slightly different than the results of full 3-D CFD calculations. This concern was reconciled by checking the blade geometry parameters in the final output of the AXIDES code, that was sent to the NASA-Lewis Engineering Design Department, against the results of the CFD design, as reported in Sanger '94 [Ref. 8]. Specifically, such blade parameters as, radial distribution of maximum thickness, and maximum thickness location, extracted from the AXIDES output, were reviewed for discrepancies; none were found. The blade shape produced by the AXIDES code was identical to the blade specified in the input. This appeared to have been accomplished by completely specifying all blade parameters in the input file. The aerodynamic output was of no interest to the designer. Aerodynamic input data were used simply to fill in the spaces of the input data set and did not represent the performance generated when the code was run. Again, the AXIDES code was used simply to reproduce the geometry of a blade designed using CFD in the form required by the NASA mechanical design system.

The design produced using the AXIDES code, and henceforth referred to as the "conventional design", was to represent what the Sanger design would have looked like if it had been sent for mechanical analysis directly after the initial design parameters were fixed. The blades were designed by taking the final form of these initial parameters, which Sanger used to build his "guess" of the blade shape, and inputting them back into the AXIDES code. In this case, however, the input file was modified to produce blade shapes for fabrication instead of merely calling for flow-field description, as had been done in the Sanger design. This was accomplished by changing the OP parameter to COORD and

using defaults for incidence angle and deviation angle by choosing 2-D for input parameters AA, and BB. The 2-D option resulted in the use of calculations specified in NASA SP-36 [Ref. 16], for these angles. Additional modifications to the input file included setting option CC to OPTIMUM, which assigned a value to the turning rate ratio of the blade element segments using an empirical function of inlet relative Mach number; setting option DD to shock, which placed the transition point at the location of the shock; and setting option EE to TRAN, which located the maximum thickness point at the transition point. A copy of the input file, and output file are located in Reference 10. A detailed description of the AXIDES code available input options, can be found in Appendix A, Section 2, and Reference 9.

3. Results Of Comparison

As previously noted, the intent of the Sanger design was to produce blading with increased loading at lower tip speeds. A plot of rotor diffusion factor, indicative of loading on the blade, is shown in Figure 4. It is clear from this plot that the loading on the Sanger rotor is larger over 90% of the blade than that of the "conventional" design. Using the detailed picture of the flow-field provided by the CFD code, the designer was able check for flow separation along the suction surface of the blade as he increased the amount of turning imparted to the flow. Figure 5 shows the amount of energy addition provided by the rotor in the form of total temperature ratio. Figure 6 illustrates the increase in total pressure ratio across the rotor. The plots indicate an increase in total pressure ratio and energy addition produced by careful analysis of the flow within the blade row. The blade sections for the conventional design and the Sanger design are shown in Figure 7. This figure displays the blade sections at 90%, 50%, and 20% span, from the hub. Looking closely at these sections, it can be seen that the curvature on the suction surface of the Sanger rotor, near the leading edge, is very small. This was done to minimize the supersonic acceleration of the flow as it approached the shock, and therefore reduce its strength. The AXIDES code used in the design of the conventional blade also attempted

to account for the effects of a large inlet relative Mach number. This was accomplished by activating the blade definition option OPTIMUM, located in the input data set. It can be seen, however, that the curvature in the leading-edge portion of the conventional blade, although modified, is still larger than on the Sanger blade. The turning of the flow was accomplished further aft on the blade, as can be seen in the distribution of blade maximum thickness location shown in Figure 8. The losses across the rotor were kept nearly the same as the conventional blade. A plot of the distribution of loss coefficient is shown in Figure 9.

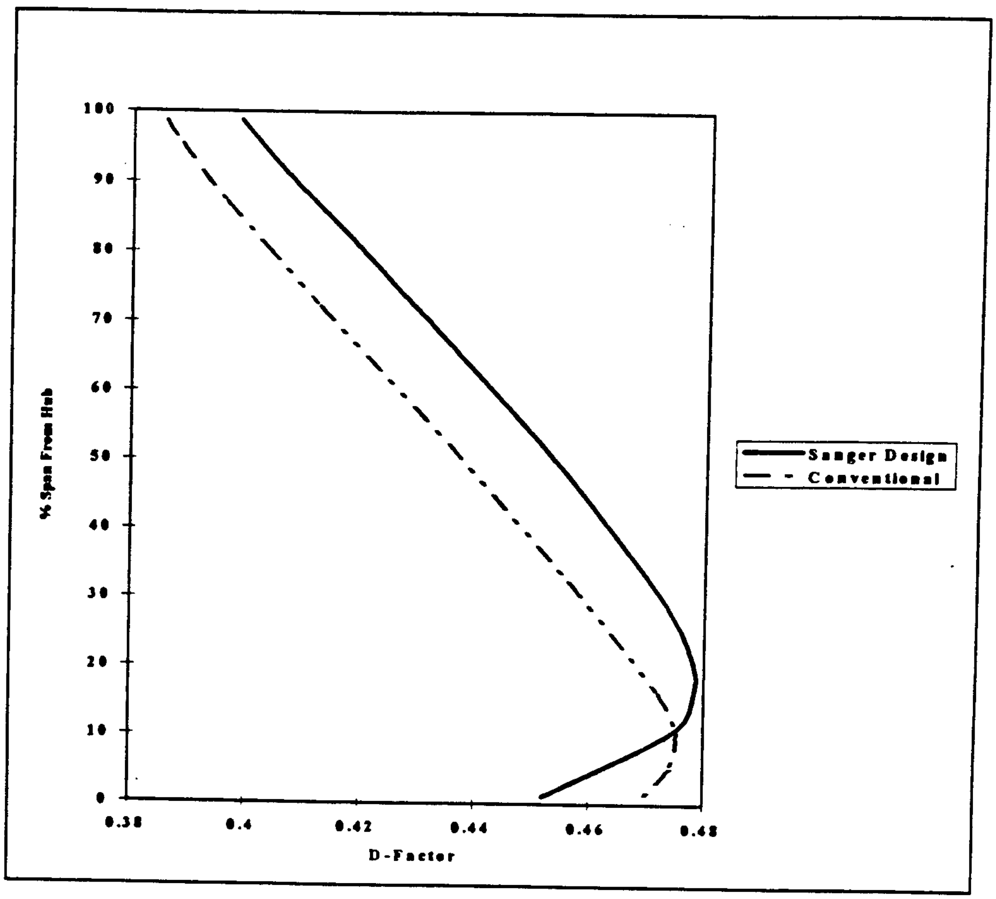

Figure 4. Rotor diffusion factor.

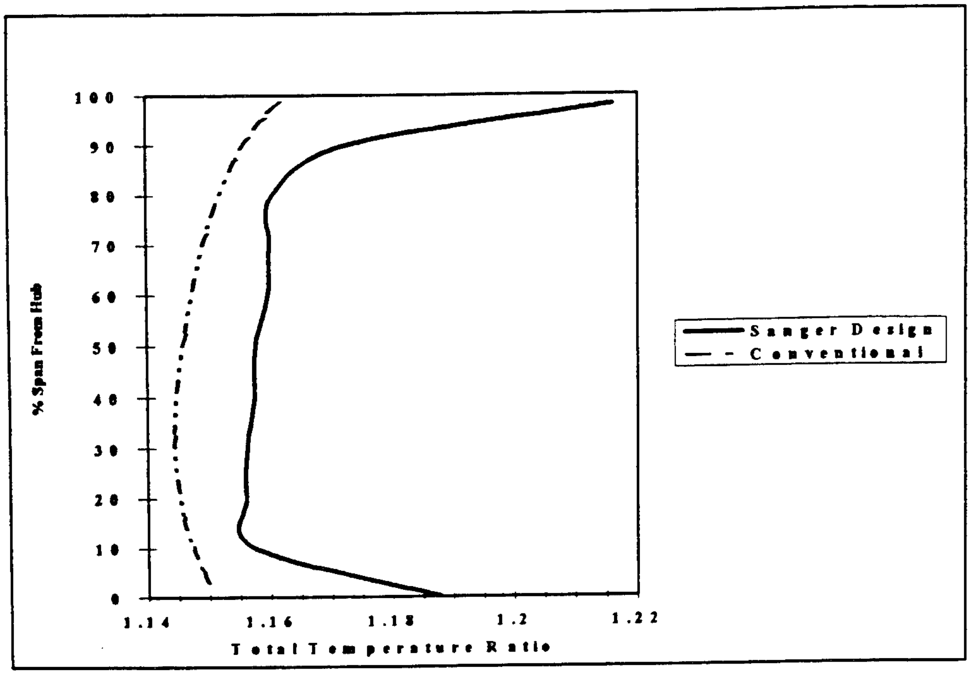

Figure 5. Total temperature ratio across the rotor.

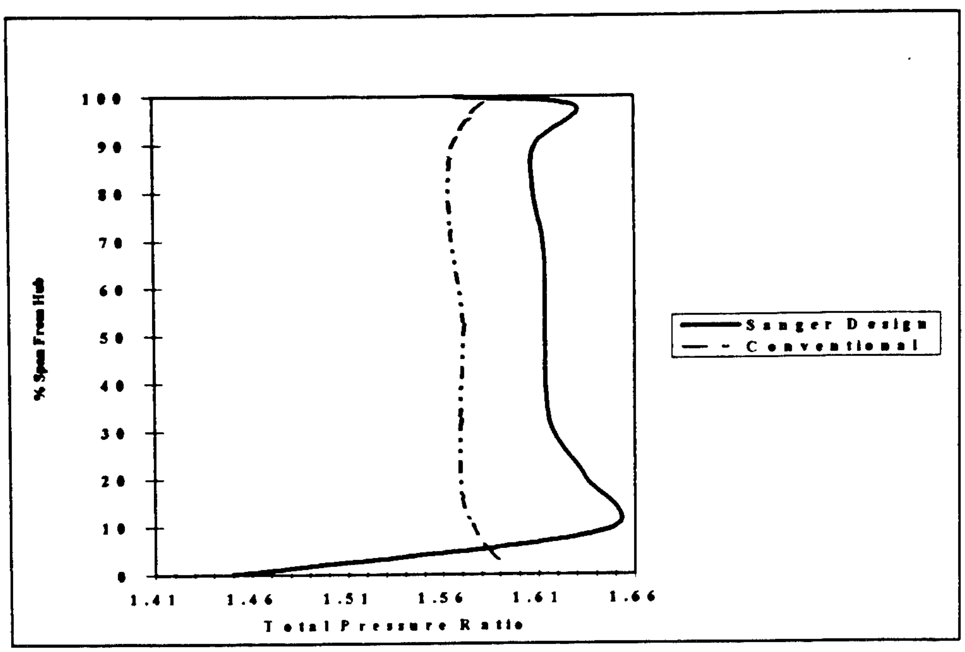

Figure 6. Total pressure ratio across the rotor.

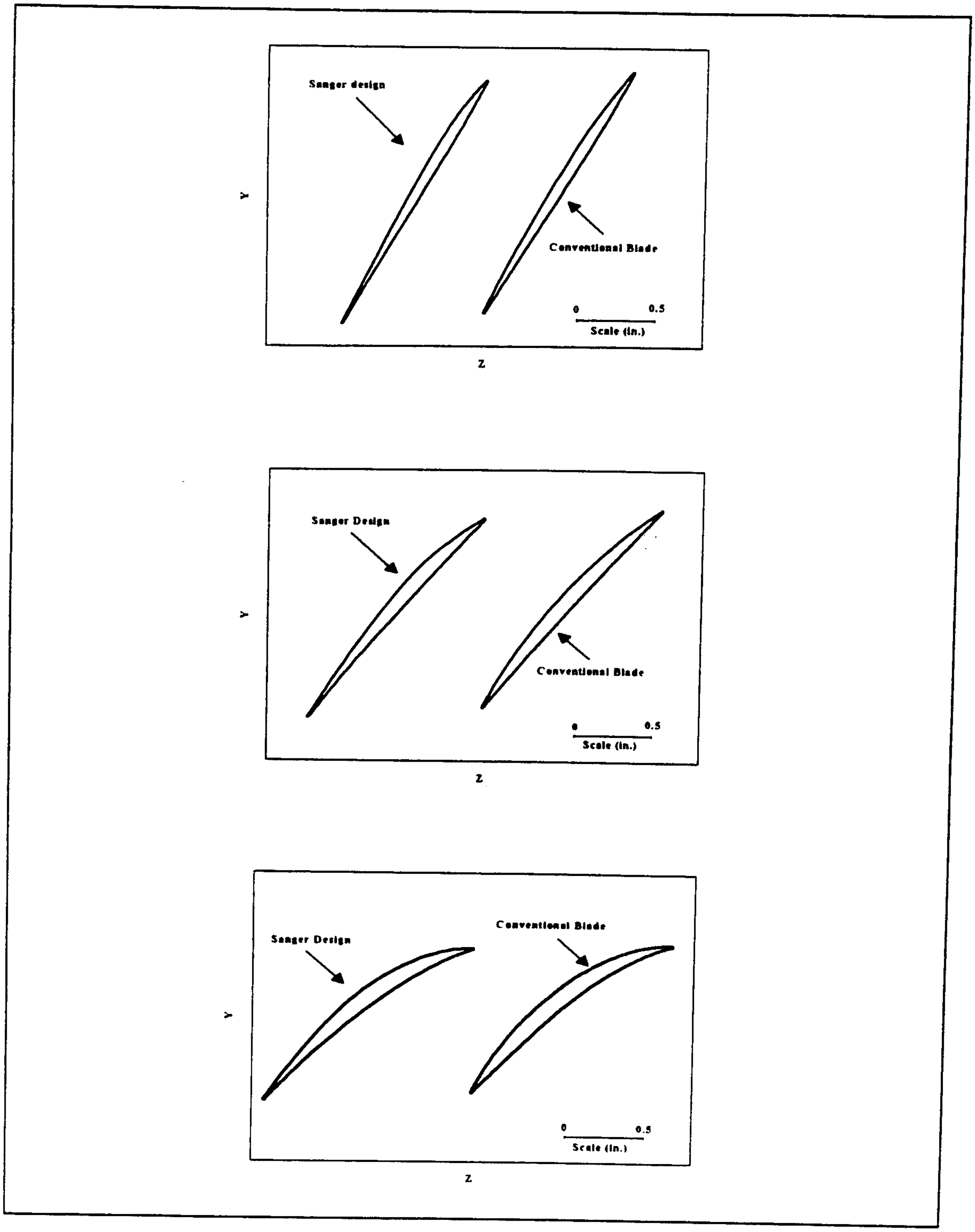

Figure 7. Tip, mean-line and hub blade sections (from top).

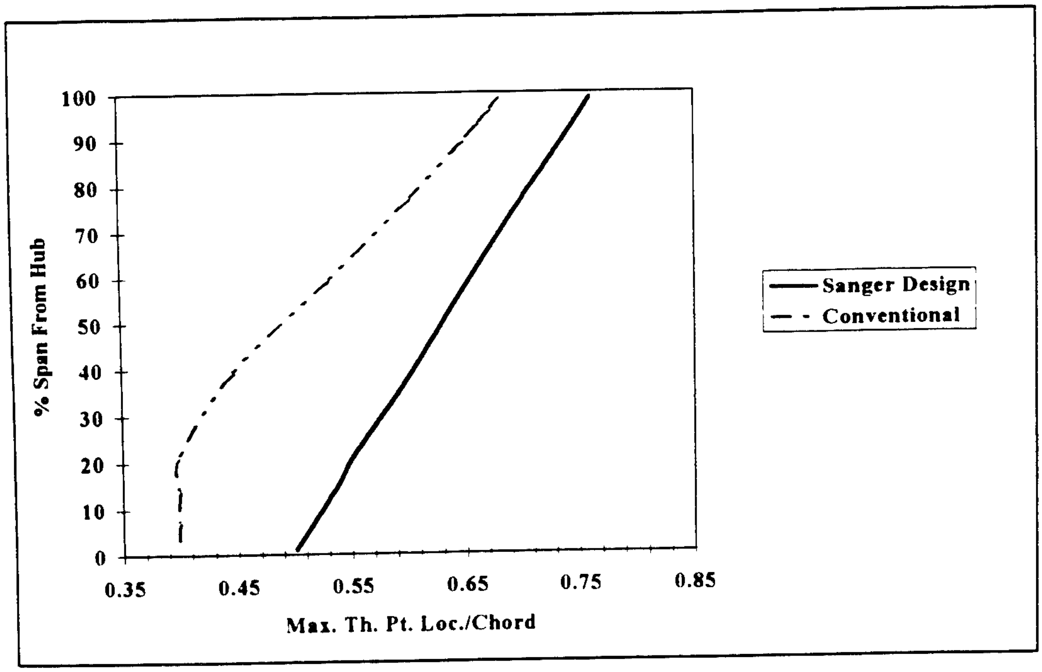

Figure 8. Rotor maximum thickness point location.

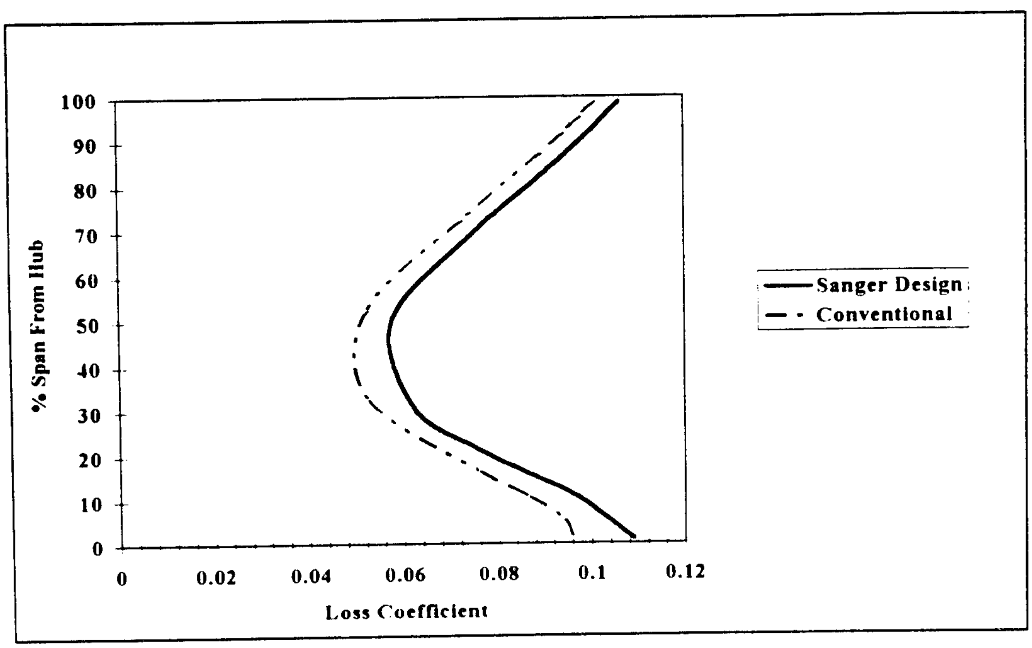

Figure 9. Rotor loss coefficient distribution.

The preceding comparisons show that the Sanger blading inputs a larger amount of work than blading designed using 2-D methods alone, while maintaining very similar through-flow and loss profiles. Assuming that the CFD code used in the design predicts the 3-D flow field accurately, the design represents a step forward toward optimizing the design of highly loaded, efficient, transonic blading.

III. PREPARATIONS FOR TESTING

A. OVERVIEW

The transonic stage designed at NASA-Lewis, was designed to be installed in the NPS/TPL transonic compressor test rig, which is shown schematically in Figure 1. Since the rig had not been operated since 1986, an evaluation of its condition, and overhaul of some its components was necessary. This section gives an account of the preliminary evaluation and subsequent overhaul, to date, required to prepare the machine to test the new design.

B. PRELIMINARY TEST RUNS

Preliminary test runs of the transonic compressor test rig were conducted in early 1995. The tests were run with the existing machine as it was left, with the initial rotor, designed Dr. Vavra, still installed. This testing was conducted to become familiar with the operation of the test rig and to determine the extent of overhaul necessary to return it to routine working order. The operating procedure is given in Appendix C.

A total of four tests were run over a period of two months. The first test was considered a basic operational check to make sure the machine would turn over with no major component failure. The rig was accelerated up to 5,000 RPM, un-throttled, with the inlet piping removed to prevent any deposits in the piping from being pulled into the blading. During this test the following mechanical aspects of the machine were monitored,

1. Pressure ratio across the laboratory 12 stage axial compressor supplying air to the drive turbine.
2. Balance air used to provide relief of the axial load on the high speed compressor bearings.
3. Test rig rotational speed.
4. Drive turbine and compressor bearing temperatures.

All of these indications were monitored at the test control panel. A photograph of the control panel is given in Appendix C.

The results of the operational check were encouraging. Although, the test rig had not been operated for many years, there was no appearance of malfunction or unusual operation. The tests that followed were conducted in the same manner, however the RPM was increased with each run, to a final value of 20,000 RPM. During the testing, the bearing temperatures were monitored and compared with values recorded from test runs conducted years earlier. These values remained nearly identical to those previously recorded until approximately 15,000 RPM (50% design speed). Above 15,000 RPM the bearing temperatures increased at a greater rate than previously documented. By adjusting the oil-mist cooling air and oil supply settings, the temperatures of the bearings supporting the turbine-drive shaft and the downstream end of the compressor shaft were controlled to within 2 degrees of earlier recorded values. This was accomplished by reducing the oil mist drop rate from approximately 80 drops per minute to 12 drops per minute, and increasing air supply pressure from 20 psi to 35 psi. The bearings supporting the upstream end of the compressor drive shaft, however, failed to respond to the changes in the cooling system. They remained approximately 25 degrees high and continued to increase at a rate of approximately 1 degree per hour.

The decision was made to tear down the compressor in an effort to resolve the problem with cooling of the compressor inlet bearings, and to check the bearings for any damage that might have occurred due to the high temperatures. Additionally, a decision was made to leave the turbine-drive unit intact since no problems in its operation had been revealed.

C. OVERHAUL

The transonic compressor test rig was a unique machine that had undergone several modifications over the years. Although some modifications were documented, the

overhaul that was conducted for the present project revealed that some of the changes made to had not been recorded. Additionally, the procedure involved in disassembling and reassembling the test rig was undocumented. The overhaul presented a significant challenge because of the mechanical complexity inherent in the arrangement of a high-speed air turbine driving a high speed research compressor. The goal was first to determine the method by which the rig was to be disassembled and then to carefully disassemble and reassemble without causing damage to any of the mostly non-standard components. During the course of the tear down and rebuild effort, video tape was taken to document the procedure.

1. Cooling Of The High Speed Bearings

The driving consideration behind the overhaul was the problem encountered with bearing cooling. Disassembly of the compressor hub revealed that, of the two cooling lines intended to provide oil-mist air to the compressor inlet bearings, one was completely disconnected. A second line which had not been indicated on the original design drawings, was bent so that no air could flow through it. Figure 10 shows a drawing of the compressor hub assembly. The bearings, notably the ones to the right, were not receiving the oil-mist air supply needed to cool them. To correct the problem the cooling lines were fitted with new tubing. As an indication of previous problems with bearing temperatures, a one-eighth inch copper water cooling line was found encircling the inner compressor hub. This water cooling device was not shown on the original drawings, nor recorded in any available test log.

2. Torque Measurement system

The torque acting on the test rig rotor drive shaft was measured by the deflection of a cantilever beam. The beam extended between the outer portion of the compressor hub, that rotated on bearings, and the inner hub annulus which was stationary (see Figure 10). The rotation of the outer hub was a result of the swirling air-flow exiting the rotor

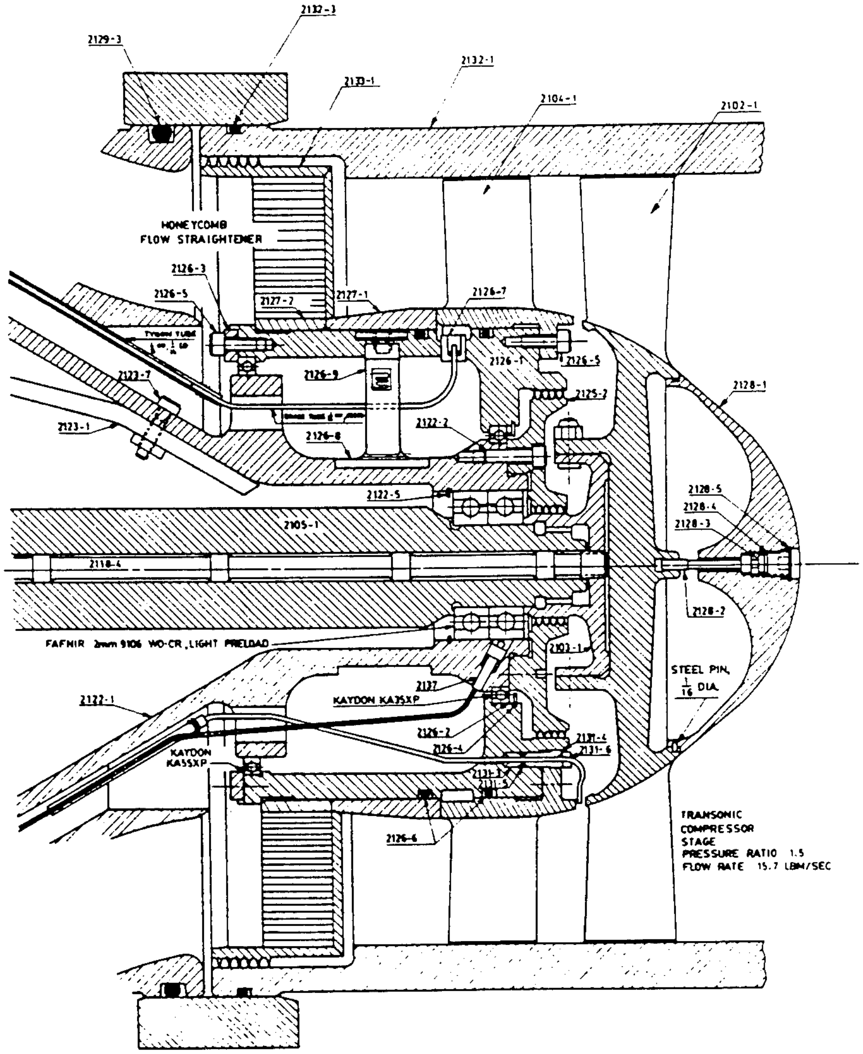

Figure 10. Compressor hub assembly.

and impinging on the stator. The stator removed most of the swirl component of the velocity, and a honeycomb flow straightener, removed the residual. The stator and flow straightener were both mounted on the outer hub which rotated on the outer hub bearings. The cantilever beam (torque balance), whose fixed end was attached to the outer hub and free end was constrained by a channel fixed to the inner stationary hub annulus, deflected as it tried to prevent relative rotation. Four strain gauges, mounted on the cantilever beam, provided the signal that was a measure of the torque imparted to the air-flow by the rotor.

A static calibration of the torque balance was conducted in preparation for the tests to follow overhaul. A significant drift in the strain gauge output was found. A plot of the calibration is shown in Figure 11. The calibration was performed using weights hung from a 20.01 inch moment arm which was mounted on the outer hub. The load was increased from zero to 35 pounds in five pound increments. A zero of -1.0 milli-volts was set on the output voltage display. This was done because the beam appeared to have some pre-load on it and the bridge output could not be set to zero. The plot clearly indicates repeatability, however, the measurements, conducted for two static load and unload cycles, were taken after the output settled down after a drift of approximately two milli-volts per second. This required waiting an average of 15 minutes from the time the load was changed until the time the readings were taken. The time dependent nature of the static load, as well as other difficulties with the torque measurement, were documented for an early compressor test program using the same rig, by R.P. Shreeve [Ref. 17].

After careful consideration of the problem, and the ramifications of possible changes to the system, modification of the torque balance assembly was made as shown in Figure 12. The first change was an attempt to insure the fixed end of the cantilever beam was firmly "encased" in the outer hub. Four set screws, mounted in the outer ring were installed to apply pressure to the top of the beam and secure it in place. They replaced the single (center) set screw in the original design. Additionally, the channel fixed to the inner hub annulus was modified. The side of the channel resisting the load was drilled and fitted

with a three-eighths inch ball bearing. This was done to insure a point load would be transmitted at the free end of the cantilever beam.

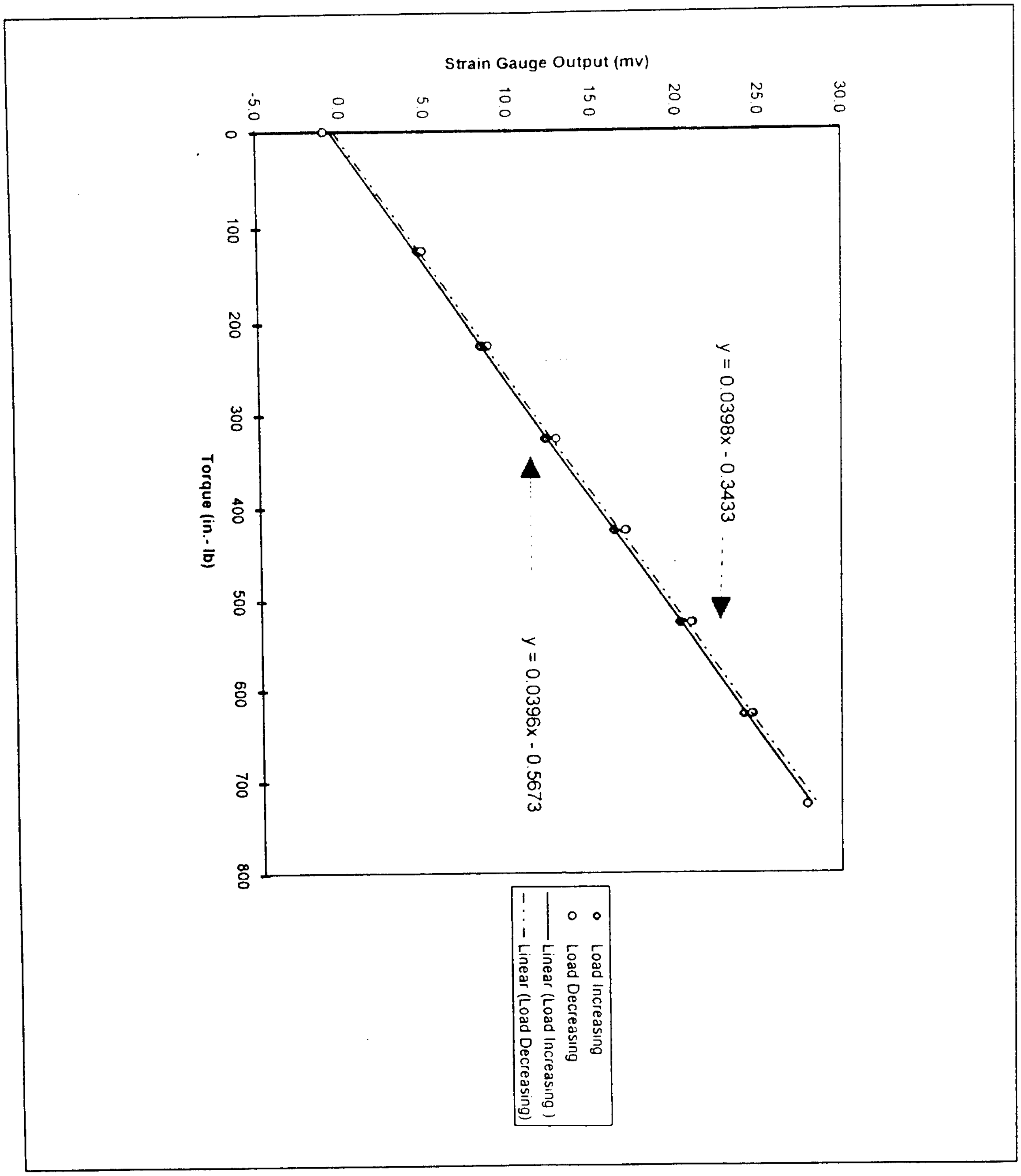

Figure 11. Torque balance calibration (first).

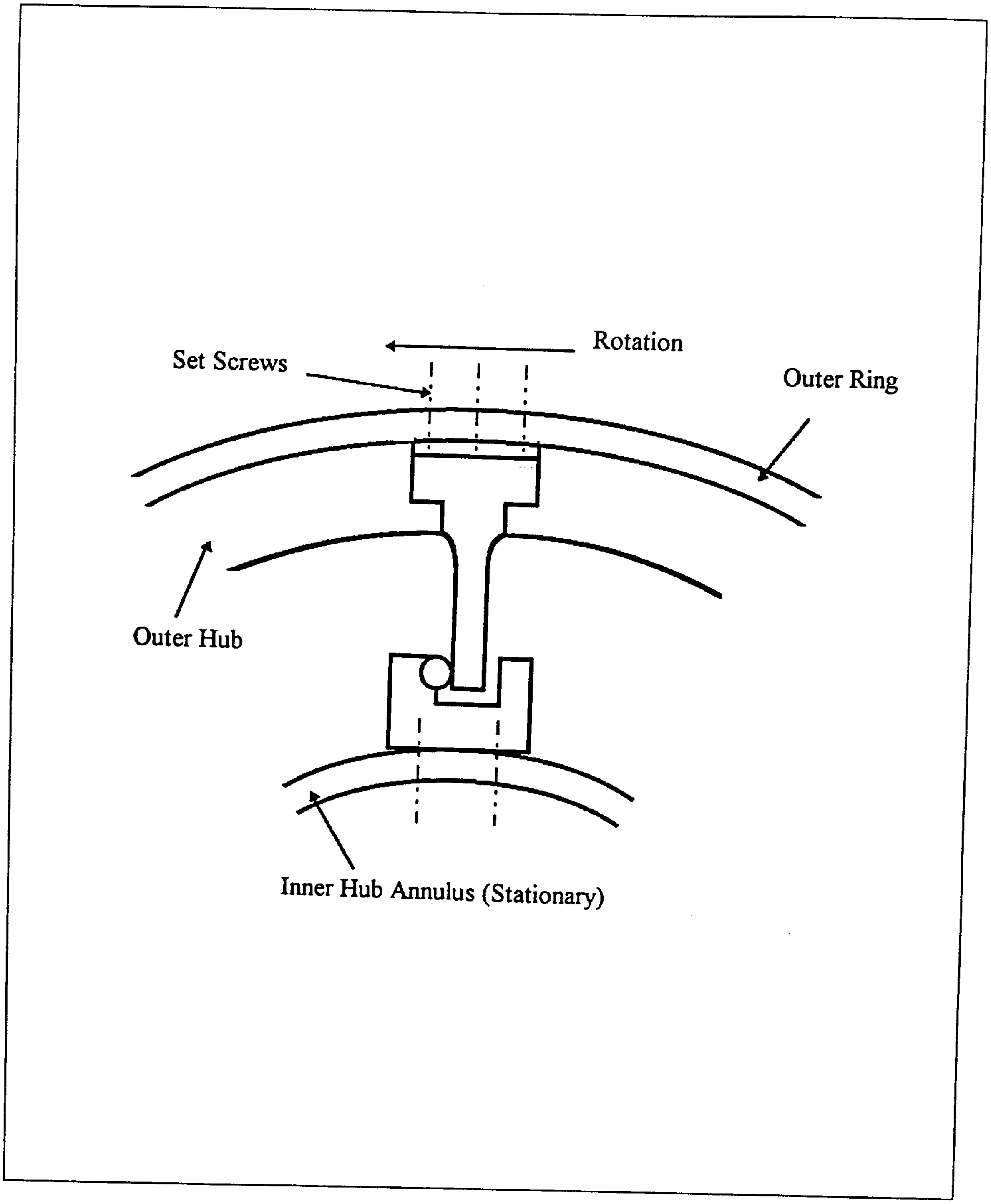

Figure 12. Torque balance modifications.

A second calibration of the torque balance was conducted in the same manner as the first with the exception that the zero-load output was set at 0.1 milli-volts. A plot of the calibration is shown in Figure 13. The results indicated that the drift in the output reading had disappeared. However, as can be seen clearly in Figure 13, there was a distinct lack of repeatability over the four load and unload cycles. The output seemed to settle out after the second cycle, however, the overall uncertainty for the four data sets was in the vicinity of 10%. Since the uncertainty in the torque measurement gives an equal uncertainty in the measurement of efficiency the lack of repeatability is unexceptable. However, since the intent of the overhaul effort was to return the rig to stable mechanical operation, no further modifications were attempted. Recommendations for additional modifications to the torque assembly include,

1. Installing additional set screws to attach the outer ring firmly to the outer hub, to prevent movement of the parts constraining the fixed end of the cantilever beam.
2. Fitting the existing beam with new strain gauges.
3. Replacing the existing beam and strain-gauges with a new design having a larger, rectangular fixed end.

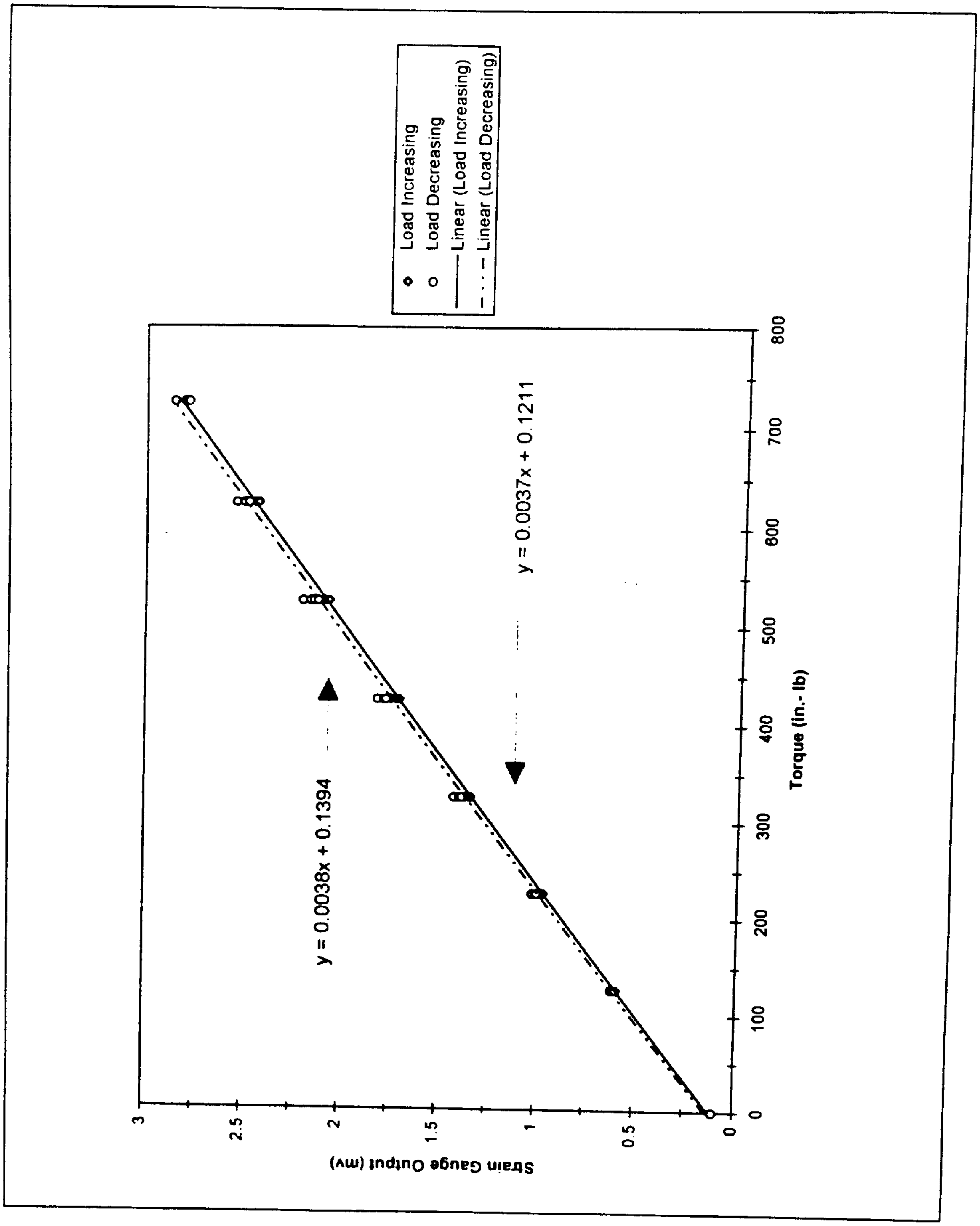

Figure 13. Torque balance calibration (second).

D. FINAL TEST RUN

A final test run of the transonic compressor was conducted up to a speed of 20,000 RPM. This testing was performed un-throttled, with the inlet piping removed. The test rig setup was similar to the preliminary test runs except for the addition of a honeycomb flow straightener and the original stator that were installed during overhaul. The duration of the test was two hours and twenty minutes. The objective of the test run was to check the mechanical operation of the rig, and in particular, the behavior of the bearing temperatures, following overhaul.

The test rig operated smoothly during the entire run, at no time indicating problems with balancing or vibration. At a speed of 15,000 RPM, the temperature of the bearings supporting the inlet end of the compressor drive shaft were stable, but reading approximately ten degrees high, relative to temperatures recorded during earlier test runs at the same RPM. As the rotational speed was increased from 15,000 RPM, to 20,000 RPM, the temperature of these bearings increased significantly. The temperature was recorded to be 143 Deg. F, and climbing at a rate of approximately five degrees per minute, when the RPM indicated 18,000. All other bearing temperatures were stable and within limits. The temperature limitations of these bearings require operating levels of less than 160 Deg. F. The RPM was reduced to 10,000 RPM and after temperatures stabilized the machine was shutdown.

IV. CONCLUSIONS AND RECOMMENDATIONS

A case study was initiated of the design of a new transonic compressor stage which is to be tested at the Turbopropulsion Laboratory at the Naval Postgraduate School. The stage was designed by Nelson Sanger of the NASA Lewis Research Center, using 3-D, CFD methods. The program of testing, scheduled to follow installation of the new stage, will provide data with which to validate those methods used in the design, and serve as a test case for still-emerging analysis codes.

The process followed by the designer was reviewed and a version of the code (AXIDES), which was used early in the design was installed and made operational at the School. The code was used successfully both to examine the design process for the new stage, and later to carry out the design of a multi-stage core compressor. In preparation for testing, the test rig was operated, partially overhauled, and operated again to 75% design speed. The following were concluded:

Stage Design

- The initial flow-field used by the designer was reproduced successfully using AXIDES, and the (conventional) blading associated with this flow-field was generated.
- More highly loaded blading was produced using CFD advanced design methods than could have resulted from the use of the AXIDES code alone.
- The differences in blade shape that enabled the higher loading were, visually, relatively subtle.
- The new stage was manufactured successfully and is ready to test after installation in the rig.

AXIDES Code

- The AXIDES code was made operational on NPS, AA Department workstations, and on the TPL PC.
- The code was run for several design cases, the input and output of which serve as examples of the varied uses of the code.

Test Rig

- Preliminary test runs were conducted up to 20,000 RPM (design speed is 30,000 RPM).
- The machine was overhauled to correct problems with cooling of the compressor inlet bearings. The bearings were in good condition and were re-installed. The cooling air supply system was checked and returned to working order.
- The torque measuring system was modified; however, a lack of repeatability remains.
- Following the reassembly, a test run was completed up to 20,000 RPM, and indicated continuing problems with the bearings at the inlet end of the compressor.
- The pressure at the rotor exit is greater when the machine is run without the inlet piping, than when the piping, screens and throttle are installed. Since the rotor exit is where the cooling air is exhausted after passing through the bearings, the higher pressure may be preventing the cooling air from circulating as intended.

The following recommendations are made:

- The "conventional" blading design should be put through CFD analysis, using a more recent 3-D code, and compared with the results of the Denton, TIP3D code.
- The tools for complete axial compressor design, including preliminary 1-D, 2-D, and 3-D CFD, codes, all now available at NPS, should be integrated.
- The AXIDES code should be upgraded to include a graphics package, and reliable interfacing with the off-design code AXIOFF.
- The transonic test-rig inlet pipe and housing should be installed, and the test rig operated, to determine if the reduced pressures at the rotor exit effect the compressor inlet bearing temperatures.
- The new stage testing program should move ahead without delay to prevent the recent experience from being lost.

APPENDIX A. AXIDES CODE

A. OVERVIEW

The AXIDES code written by Jim Crouse is a composite aerodynamic and blade design code. It uses the streamline curvature method to arrive at a full, 2-D, radial equilibrium solution of the flow between blade rows in the meridional plane, assuming steady, axisymmetric flow. The code can be used for either aerodynamic or blade design, or both. In the case where both design capabilities are required, the code performs four iterations of the aerodynamic solution, and then stacks the blades. This process is continued until the solution converges. The final blade shape is calculated after the aerodynamic solution is complete. The code can be used for either single or multistage axial compressors. A complete description of the AXIDES code can be found in Reference 9.

A version of the AXIDES code was purchased by the Naval Postgraduate School. The code is originally PC based and has been modified to run on the Department of Aeronautics and Astronautics workstations. The PC version was installed and operated on the Turbopropulsion laboratory's 486 machine. After overcoming initial difficulties with input and output assignments and initialization of variables, the code was used for the following,

1. To reproduce the initial flow-field solution used in the design of the new, NPS transonic compressor stage.
2. To reproduce the geometry of the final blade design, of the same stage, used in the mechanical analysis and fabrication of the hardware.
3. To design a stage using the strictly 2-D calculations of the code, for the comparison with the new stage, arrived at using 3-D CFD methods.
4. To design a multi-stage compressor for the AA Department Engine Design Course.

B. INPUT

Creating the input file to the AXIDES code is crucial to its successful use as a compressor design tool. Along with the need for a basic understanding of internal and turbo-machinery flows, a general understanding of the input file structure is required to produce realistic output. This section provides the tools necessary to build a working input file.

The input to the code is in the form of a formatted data field. Each piece of the data has a specific location in the data field and a specific length. If the input data is not in the correct location, the formatted READ statements in the code will not read the correct information and the program will run based on invalid input, or may not run at all.

Note :

An important note here is that a "dummy" editor, such as Notepad™ ,on the PC, or *jot*, on the workstations should be used to create or modify the input file. Other editors including DOS and word processing editors have been found to change the formatted structure of the file, however slightly, enough to move the input data out of position and prevent the correct input from being read.

Figure 14, located on page 49, shows an example working input data file. This file was provided with the code in an effort to get the program up and running on the AA Department machines. To arrive at a successful input file it is recommended that an example file be run first, to become familiar with the operation of the code, and then modifications to that file be made to create an original design. Five input files were used to produce this report. Four of these, namely,

- Examp.dat : The example file provided when the code was purchased,
- Approx.dat : The file used to set final preliminary design parameters, and define the desired flow-field for the new Sanger stage,
- Conv.dat : The file used to produce the "conventional" stage for the design comparison,
- Multax.dat : The file used in the design of a four stage compressor,

are provided for use as a starting point to build an input data set. The input file Examp.dat is shown in Figure 14. A copy of the output associated with Examp.dat (Examp.out), is located in Appendix B. The last three files listed above can be found in Reference 10. The fifth input file, also located in Reference 10, titled Sanger.dat, was used simply to produce fabrication coordinates and the aerodynamic input is not representative of the blades that the code designed; See Chapter II, Section B2, paragraph 1, for a discussion of this.

The input file to the code is broken up into two main sections. The first section contains general information which includes the number of stages, the flow path or casing and hub geometric coordinates, the RPM, and the desired overall pressure ratio. The second section consists of annular calculation station and blade row data. This data includes axial locations of annular stations and blade rows, boundary layer blockage estimates, the number of blades on the rotor and stator, solidity, and blade definition parameters such as leading and trailing edge radii.

Figures 15-19, located on pages 50-54, provide another look at the example input data file mentioned previously (Examp.dat). This illustration is included as an aid in identifying the input file parameters used for this particular design. It must be emphasized that this figure is <u>not</u> a working file but is included only for parameter clarification. The corresponding working input file is shown in Figure 14. Also included is an illustration of the general form of the input (Figures 20, 21, and 22, pages 55, 56, and 57), taken from notes provided by the author of the code, with all possible input parameters and associated formatting. For a complete description of the code and its input see Reference 9.

The following is a description of the input parameters used in the example input file Examp.dat. It addresses each parameter in the file in the order shown in Figures 13-17. The information provided below was extracted entirely from Reference 9, and is included merely for the readers convenience.

Indices

- I — Calculation station index
- IROTOR — Rotor index.
- J — Streamline index. Numbered from one at the tip.
- K — Loss set index.

General Input

- Column — Not an input parameter. The first three lines simply show the relationship of the data below to the 80 column FORTRAN data field.
- TITLE — The title of the design.
- ITG — Output blade fabrication coordinate specification. The output of the blade shapes produced by the code is in the form of suction and pressure surface coordinates on blade sections. These coordinates are located at uniform and round number increments of the chord-wise distance from the leading-edge. Included in the table of coordinates are the tangency points between the blade surfaces and the leading and trailing-edge ellipses. The locations of the point of tangency for the suction and pressure surfaces will be different. If the parameter ITG is set to 0, the program will insert an artificially high value of 99.9999, for the height of the surface

- ITG (cont'd) — opposite the surface that is tangent at that chord-wise distance. This clearly identifies the junction point between that surfaces and the end ellipse. The leading and trailing-edge information is provided below the table of coordinates. If ITG is set to 1, the program simply outputs the actual height of the surface opposite the surface that is tangent at that point. The tangency points must then be determined by noting the change in the surface heights near the leading and trailing-edges.
- IBR — Set equal to 0 to get error messages printed when running the code. Set equal to 1 to suppress the error message output. If set to a value greater than 1, the program will provide no error messages during the run, and stop after the performance summary is printed, printing neither radial distribution information, nor fabrication coordinates, even if specified in the input file.
- NSTRM — Number of streamlines (11 max.).
- NROW — Number of blade rows (20 max.).
- NA — Number of annular stations. Fifty maximum, including leading and trailing edges of each blade. Must be at least four prior to first blade row and three after the last.
- NLOSS — Number of loss sets input in the form of tables of correlation data.
- NTIP — Number of outer case wall geometric coordinates.
- NHUB — Number of hub geometric coordinates.
- ROT — Compressor RPM.
- FLOW — Mass flow rate (lb./sec).
- PRATIO — Desired overall pressure ratio.
- MOLWT — Molecular weight of air.

- SCALEF — Scaling factor. If set to other than 1.0, the program will scale all linear dimensions and the weight-flow to a different size compressor, by the factor indicated.
- CP(K) — Constants for specific heat polynomial.
- LUNITI — Units of input. Set equal to 1 if SI and 2 if English.
- LUNITO — Desired units of output. Set to 1 for SI and 2 for English.
- FLO(K) — Cumulative flow fraction at streamlines, from the tip.
- TO(1,J) — Inlet total temperature at streamlines from tip.
- PO(1,J) — Inlet total pressure at streamlines from tip.
- VTH(1,J) — Inlet tangential velocity at streamlines from tip.
- XTIP(I) — Axial coordinate of casing wall points.
- RTIP(I) — Radial coordinates of casing wall points.
- XHUB(I) — Axial coordinates of hub wall points.
- RHUB(I) — Radial coordinates of hub wall points.
- DLOSS(K,J,1) — Array of loss parameter correlations (five sets max.).
- DFTAB(K,J,1) — Array of diffusion factor correlations (five sets max.).

Calculation Station And Blade Row Data

- AA — Type of axial station :

  : ANNULAR

  : ROTOR

  : STATOR

  ,or, depending on location in data set,

  Incidence angle input

  : 2-D — NASA SP-36 correlations performed internal to code.

  : 3-D — NASA SP-36 correlations.

- AA (cont'd) : SUCTION Zero inc. to suction surface.

  : TABLE Input in tabular form as INC(IROW,J), at the end of associated blade rows input data set.

- ZTIP(I) Tip axial coordinate of annular station or blade stacking line.
- ZHUB(I) Hub axial coordinate of annular station or blade stacking line.
- BT (I) Tip boundary layer blockage for annular station or blade LE or TE. Can be input as a fraction of annular area, or as the displacement from the wall in inches if preceded by a negative sign.
- BH(I) Hub boundary layer blockage (same as BT except applied at hub).
- BLEED(I) Fraction of weight flow bled off at annular station or blade row.

  DLIM(IROW) Diffusion factor limit. Applies to tip for rotors and hub for stators. If limit exceeded the program will reduce the energy addition across that particular blade row and try to make it up in others that have not exceeded their limit. If all blade rows are at there limit the overall pressure ratio will be reduced.
- ALIM(IROW) Minimum relative flow angle limit leaving rotor hub, or, maximum allowable Mach number entering the stator hub. Adjustments made to satisfy limitations are the same as for DLIM except applied to flow angle and Mach number.
- CRENGY Cumulative fraction of energy input across rotor to that input across stage. If greater than 2, interpreted as rotor tip exit total temperature in degrees Rankine, and is converted to energy addition internal to program using the total temperature profile input in the form of parameters PRA-PRE.
- BMATL(IROW) Material density of rotor (lb./in.^{3}).
- NXCUT(IROW) Number of blade sections for which fabrication coordinates will be produced. If zero, the program will select this number based on

- NXCUT (IROW) (cont'd) aspect ratio. If negative, represents the number of sections desired, and program reads specific locations in a table input as parameter XCUT, at end of entire data file.
- ILOSS Loss set used for blade row. If less than or equal to 0 total pressure at the blade row exit is input instead of losses being computed internal to the program. See Reference 9 for a discussion of parameters PTT and PTC.
- OP Input option controlling amount and type of output information.
  - : APPROX Only velocity diagram output based on estimated blade edge locations.
  - : VEL. DIA. Only velocity diagram output based on blade edge locations that are input as ZTEMP, and RTEMP, at the end of the associated blade rows input data set.
  - : DESIGN Output consists of velocity diagram information only based on stacked blade edge locations computed internal to code.
  - : COORD Output includes velocity diagram and blade section fabrication coordinate information based on stacked blade edge locations.
- AB Part of incidence angle TABLE input option. If SS, the code will reference incidence angle input to the suction surface at the leading edge. Otherwise it will be referenced to the leading edge center-line.
- BB Deviation angle input.
  - : 2-D NASA SP-36 correlations.
  - : 3-D NASA SP-36 correlations.
  - : TABLE Input in tabular form as parameter DEV(IROW,J), at the end of associated blade rows input data set.

- BB (cont'd)

: CARTER Deviation calculated internal to the code using Carter's rule.

- CC

Blade element geometry input.

: CIRCULAR	Code Designs circular arc blade sections.
: OPTIMUM	Curvature at the leading edge set by an empirical function of inlet relative Mach number. Below M'1 of 0.8 the shape will be circular arc. As the relative Mach Number increases, the ratio of turning rates of the front and rear blade segments is reduced to avoid large shock losses.
: TABLE	Ratio of front to rear segment turning rates. Input in tabular form as PHI(IROW), at the end of associated blade rows input data set.

- DD

Input location of transition point.

: CIRCULAR	Transition point between front and rear segments put at mid-chord.
: SHOCK	Transition point located at suction surface shock attachment point.
: TABLE	Input as TRANS(IROW,J), in tabular form, at the end of the associated blade rows input data set.

- EE

Maximum thickness location input.

: TRAN	Locates the max. thickness point at the transition point.
: TABLE	Maximum thickness location input as ZMAX(IROW,J), in tabular form, at the end of the associated blade rows input data set.

- EB — Used with TABLE option of max. thickness location. If LE, the maximum thickness location is input as a fraction of blade chord from the leading edge. Otherwise it is input as a fraction of the chord from the transition point.
- CHOKE(IROW) — Choke margin input. If greater than 0 the program will adjust incidence angle in an attempt to provide this margin. If 0 the code makes no adjustment.
- BLADES(IROW) — Number of rotor or stator blades.
- SOLID(IROW) — Input solidity.
- TILT(IROW) — Stacking axis tilt angle.
- PRA-PRE(IROW) — Coefficients of the input pressure or temperature profile polynomial at the exit of a rotor, or tangential velocity at the exit of a stator. The pressure profile is input here if stage energy addition is input using CRENGY. If the rotor tip exit total temperature profile is input as the parameter CRENGY, the total temperature profile polynomial coefficients are input here and the pressure profile is input using PTT and PTC.
- TALE-TDLE(IROW) — Polynomial coefficients describing the distribution of the ratio of blade element leading-edge radius to chord.
- TATE-TDTE(IROW) — Same as TALE-TDLE except applied to the trailing-edge.
- TAMAX-TDMAX(IROW) — Polynomial coefficients describing the distribution of the ratio of blade element maximum thickness to chord.

- CHORDA-CHORDC(IROW) Polynomial coefficients describing the distribution of the ratio of blade element chord to tip chord on a projected plane.
- IDEF(IROW) Blade section definition parameter. If 0 the blade element surfaces and centerline are described by dk/ds = const. If not 0 they are defined by a fourth-degree polynomial input on the next line of the data set. See Reference 9, for a more complete discussion.
- INC(IROW,J) Incidence angle array on streamlines.
- DEV(IROW,J) Deviation angle array on streamlines.
- PHI(IROW,J) Inlet/outlet segment turning rates on streamlines.
- TRANS(IROW,J) Transition point location on streamlines.
- ZMAX(IROW,J) Maximum thickness point location on streamlines.

C. CODE EXECUTION

The name of the executable file running on the AA Department workstations, and a 486 PC at the Turbopropulsion laboratory is Stream. To run the code on the workstations simply type **stream** and **enter**. When running the code on the PC, you must first activate the extended memory by typing **os386** and **enter**, this is a requirement of the FORTRAN compiler, and then **up stream** and **enter**. At this point you will be prompted for the name of the input data file. This data file must be located in the same directory as the executable file. If you stick to a prefix of less than seven alpha-numeric positions, and a suffix of three letters, e.g. NASAR20.DAT, you will be O.K. After typing in the name of the input file press enter and you will immediately be prompted for the name of the output file. Use the same direction for the name of this file as was used for the input file. After typing in the output file name press enter again. If the code has any trouble reading the input file the program will stop at the point where the difficulty was encountered. By

checking the output file that, will be printed up until the time of the error, you should be able to find the source of the error in the input.

<u>Reminder</u> :

An important note here is that a "dummy" editor, such as Notepad^{TM} ,on the PC, or *jot*, on the workstations should be used to create or modify the input file. Other editors including DOS and word processing editors have been found to change the formatted structure of the file, however slightly, enough to move the input data out of position and prevent the correct input from being read.

Once the input is read the program will ask if you want an off design output file to be created. At the time of this report the off-design code that was written to interface with the design code was undergoing modifications. If yes or Y is selected the program will create an input data set to the off-design code, however, given that the off-design program is not up and running it would be prudent to type N. After the off-design prompt the program will enter its aerodynamic and blade design (if activated) iteration. It is recommended that the input parameter IBR be set to zero until the program is running to take advantage of any error messages displayed during these iterations. After the programs aerodynamic solution converges, you will be prompted to reset blade angles. This option has not been exercised. It is up to the reader to investigate this "uncharted territory". If N is entered at this prompt, the program will continue by stacking the blades one final time and printing the coordinates. The output and, if selected, the off-design input file will be placed in the same directory as the executable and the input files.

D. OUTPUT

The output of the code is broken up into four sections, consisting of the following;

1. A summary of the input.
2. Velocity diagrams and flow-field information at annular and blade edge calculation stations.
3. Stage performance summary.
4. Fabrication coordinates if blade design option is activated.

Additionally, iteration output is provided, after the input summary, if the error message parameter IBR is set to zero. A copy of the output for the five runs of the code, as described in part A of this appendix, is located in Reference 10.

The output of the code is formatted in a landscape orientation. Because of the length of the file, up to more than eighty pages for a multistage compressor, the file must be printed from a word processor on a PC. The conversion process involved in transferring the file from DOS to the word processor tends to change the layout. Attempts to print the correct layout of the output on a PC were unsuccessful. However, using the following command,

>/usr/local/bin/a2ps.5.2 -p -nH -l -1 -ns -nP -F8.5 FILENAME | lp -dhp3si_1

on the AA Department workstations, it was possible to print the output. The current operation of the networking system requires this exact input to specify all the parameters needed for printing.

A final note concerning the output is that if the program is run using the PC version, the output is broken up into two parts. The first part uses the name defined by the user, and contains the performance information. The second part is located in a separate file, using the same prefix and .COO for the suffix, and contains the blade fabrication

coordinate data. The fabrication coordinates of the output blade design are given for the suction and pressure surfaces on planes parallel to the axis of rotation, relative to the chord, and relative to the axial direction ("turbomachinery orientation"). When running the program on the workstations these files are combined in the user defined output file. Recall that the fabrication-coordinate data are only output when the blade design option is activated.

E. CONCLUDING REMARKS

As noted previously, the AXIDES code is a 2-D code that produces the aerodynamic and blade design (if desired), of single or multistage axial compressors. The run time of the code is measured in seconds, and the output of the code is in a form that can be readily used in mechanical analysis routines and in the fabrication process. The AXIDES code is available commercially and can be conveniently used on a personal computer. Although the code is based on 2-dimensional flow theory, if the application for the compressor being designed does not require "cutting edge" design technology, the short run time and conveniently formatted output make the AXIDES code a powerful tool to use. It is understood that smaller companies that design compressors for use primarily in an industrial capacity, and not for high performance aircraft, currently use the AXIDES code as a final design tool. These companies can not make a major investment in the development of their own design system and "reverse engineering" data base as do the larger aircraft engine companies. Equally, they can not afford the engineering and computer costs of using sophisticated CFD analysis codes.

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Sep 12 1995 18:00                    Examp.dat                    Page 1

        First Stage Redesign of NASA 2 Stage  -  AR = 1.52                    1    0
   11     2     8     3    20    20  16100.0    29.484     1.574    28.9700    1.0000
        .23762070E+00          .39556990E-04         -.28462996E-06                  1
        .81650840E-09         -.81993708E-12          .28442579E-15                  1
    .1257     .2457     .3600     .4686     .5714     .6686     .7600     .8457
    .9257    1.0000
   288.17    288.17    288.17    288.17    288.17    288.17    288.17    288.17
   288.17    288.17    288.17
  10130.0   10130.0   10130.0   10130.0   10130.0   10130.0   10130.0   10130.0
  10130.0   10130.0   10130.0
    .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
    .0000     .0000     .0000
 -35.5600  -30.4800  -25.4000  -20.3200  -15.2400  -12.7000  -10.1600   -7.6200
  -5.0800   -2.5400    0.0000    4.0640    5.0800    7.6200   10.9730   12.7000
  15.2400   17.7800   20.3200   24.0000
  25.4000   25.4000   25.4000   25.4000   25.4000   25.4000   25.4000   25.4000
  25.4000   25.4000   25.3900   25.1460   25.1460   25.1460   25.1460   25.1460
  25.1460   25.1460   25.1460   25.1460
 -35.5600  -30.4800  -25.4000  -20.3200  -15.2400  -12.7000  -10.1600   -7.6200
  -5.0800   -2.5400    0.0000    4.0640    5.0800    7.6200   10.9730   12.7000
  15.2400   17.7800   20.3200   24.0000
   7.3020    7.3020    7.4930    8.2550    9.1440    9.5890   10.0960   10.5150
  11.0490   11.7470   12.6680   13.9700   14.3360   14.7320   15.2400   15.2400
  15.2400   15.2400   15.2400   15.2400
  .0167   .0199   .0243   .0312   .0406   .3000   .4000   .5000   .6000   .7000
  .0123   .0143   .0176   .0222   .0289   .3000   .4000   .5000   .6000   .7000
  .0100   .0113   .0132   .0163   .0210   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0090   .0103   .0122   .0153   .0200   .3000   .4000   .5000   .6000   .7000
  .0092   .0110   .0140   .0182   .0243   .3000   .4000   .5000   .6000   .7000
  .0104   .0127   .0168   .0221   .0296   .3000   .4000   .5000   .6000   .7000
  .0309   .0336   .0373   .0430   .0508   .3000   .4000   .5000   .6000   .7000
  .0272   .0290   .0320   .0362   .0423   .3000   .4000   .5000   .6000   .7000
  .0250   .0263   .0282   .0313   .0360   .3000   .4000   .5000   .6000   .7000
  .0230   .0239   .0253   .0280   .0310   .3000   .4000   .5000   .6000   .7000
  .0211   .0220   .0234   .0261   .0296   .3000   .4000   .5000   .6000   .7000
  .0212   .0222   .0236   .0264   .0299   .3000   .4000   .5000   .6000   .7000
  .0214   .0226   .0241   .0269   .0306   .3000   .4000   .5000   .6000   .7000
  .0218   .0231   .0248   .0278   .0317   .3000   .4000   .5000   .6000   .7000
  .0233   .0248   .0270   .0303   .0347   .3000   .4000   .5000   .6000   .7000
  .0272   .0290   .0320   .0362   .0423   .3000   .4000   .5000   .6000   .7000
  .0294   .0317   .0358   .0441   .0486   .3000   .4000   .5000   .6000   .7000
  .0                                                                      -2.0
  .0                                                                       .05
  .0                                                                       .03
  .0
  .0
  .0
  .0
  .0
  .0
  .0
  .0
ANNULAR     -32.0000  -32.0000     .0000     .0000     .0000
ANNULAR     -21.0000  -21.0000     .0000     .0000     .0000
ANNULAR     -13.0000  -13.0000     .0000     .0000     .0000
ANNULAR      -7.0000   -7.0000     .0000     .0020     .0000
ANNULAR      -3.0000   -3.0000     .0030     .0030     .0000
ROTOR         2.0500    2.0500     .0070     .0070     .0000
    .4600   -20.0000     .0100     .0100     .0000    1.0000     7.823         0
    1      COORD     TABLE SS  TABLE     TABLE     TABLE     TABLE LE      .0000
  44.0000    1.3000     .0000     .0000     .0000     .0000     .0000     .0000
    .0055     .0000     .0000    0.0000     .0055     .0000     .0000    0.0000
    .0327     .0496     .0000    0.0000     .0000     .0000     .0000         0
     .00       .00       .00       .00       .00       .00       .00       .00
     .00       .00       .00
    5.40      4.40      2.90      2.60      2.80      2.90      2.90      3.00
    3.60      6.20      7.80
    0.00      0.25      0.50      0.75      1.00      1.00     1.000      1.00
   1.000     1.000     1.000
   0.700     0.680     0.660     0.640     0.620.    0.600     0.540     0.480
   0.420     0.360     0.300
```

```
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    0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500
   0.5000    0.5000    0.5000
STATOR       9.4000    9.4000     .0100     .0100     .0000
    .7000    1.0000     .0100     .0100     .0000                              0
    2      COORD     TABLE SS  TABLE     TABLE     SHOCK     TABLE LE      .0000
  48.0000    1.2700     .0000     .0000     .0000     .0000     .0000     .0000
    .0061    0.0080     .0000     .0000     .0061    0.0000     .0000     .0000
    .0667    0.0200     .0000     .0000     .0000     .0000     .0000         0
    0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
    0.00      0.00      0.00
   14.20     11.10      9.40      8.90      8.80      8.80      8.80      8.70
    8.70      8.80      9.10
    0.50      0.50      0.50      0.50      0.50      0.50      0.50      0.50
    0.50      0.50      0.50
     .50       .50       .50       .50       .50       .50       .50       .50
     .50       .50       .50
ANNULAR      14.0000   14.0000     .0150     .0150     .0000
ANNULAR      18.0000   18.0000     .0150     .0150     .0000
ANNULAR      23.0000   23.0000     .0150     .0150     .0000
```

Figure 14. Examp.dat input data file.

```
*********************************** COLUMN ***********************************
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

                              TITLE                                   ITG IBR
                              =====                                   === ===
    First Stage Redesign of NASA 2 Stage  -  AR = 1.52                  1   0

NSTRM NROW  NA NLOSS NTIP NHUB    ROT       FLOW     PRATIO   MOLWT    SCALEF
===== ====  == ===== ==== ====    ===       ====     ======   =====    ======
   11    2   8     3   20   20  16100.0    29.484    1.574   28.9700   1.0000

                             CP(K),K=1,3                               LUNITI
                             ===========                               ======
      .23762070E+00         .39556990E-04         -.28462996E-06            1

                             CP(K),K=4,6                               LUNITO
                             ===========                               ======
      .81650840E-09        -.81993708E-12          .28442579E-15            1

                     CUMULATIVE FLOW FRACTION AT STREAMLINES
                     =======================================
   .1257     .2457     .3600     .4686     .5714     .6686     .7600     .8457
   .9257    1.0000

                     INLET TOTAL TEMPERATURE AT STREAMLINES
                     ======================================
  288.17    288.17    288.17    288.17    288.17    288.17    288.17    288.17
  288.17    288.17    288.17

                      INLET TOTAL PRESSURE AT STREAMLINES
                      ===================================
 10130.0   10130.0   10130.0   10130.0   10130.0   10130.0   10130.0   10130.0
 10130.0   10130.0   10130.0

                    INLET TANGENTIAL VELOCITY AT STREAMLINES
                    ========================================
   .0000     .0000     .0000     .0000     .0000     .0000     .0000     .0000
   .0000     .0000     .0000

                      AXIAL COORDINATE OF CASING WALL POINTS
                      ======================================
-35.5600  -30.4800  -25.4000  -20.3200  -15.2400  -12.7000  -10.1600   -7.6200
 -5.0800   -2.5400    0.0000    4.0640    5.0800    7.6200   10.9730   12.7000
 15.2400   17.7800   20.3200   24.0000
```

Figure 15. Examp.dat input data file (breakdown).

```
*********************************** COLUMN ***********************************
         1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

                    RADIAL COORDINATE OF CASING WALL POINTS
                    =======================================
 25.4000   25.4000   25.4000   25.4000   25.4000   25.4000   25.4000   25.4000
 25.4000   25.4000   25.3900   25.1460   25.1460   25.1460   25.1460   25.1460
 25.1460   25.1460   25.1460   25.1460

                      AXIAL COORDINATE OF HUB WALL POINTS
                      ===================================
-35.5600  -30.4800  -25.4000  -20.3200  -15.2400  -12.7000  -10.1600   -7.6200
 -5.0800   -2.5400    0.0000    4.0640    5.0800    7.6200   10.9730   12.7000
 15.2400   17.7800   20.3200   24.0000

                      RADIAL COORDINATE OF HUB WALL POINTS
                      ====================================
  7.3020    7.3020    7.4930    8.2550    9.1440    9.5890   10.0960   10.5150
 11.0490   11.7470   12.6680   13.9700   14.3360   14.7320   15.2400   15.2400
 15.2400   15.2400   15.2400   15.2400

         LOSS PARAMETER ARRAY              DIFFUSION FACTOR PARAMETER ARRAY
         ====================              ================================
                                   SET #1
                                   ======
  .0167   .0199   .0243   .0312   .0406   .3000   .4000   .5000   .6000   .7000
  .0123   .0143   .0176   .0222   .0289   .3000   .4000   .5000   .6000   .7000
  .0100   .0113   .0132   .0163   .0210   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0080   .0089   .0103   .0130   .0165   .3000   .4000   .5000   .6000   .7000
  .0090   .0103   .0122   .0153   .0200   .3000   .4000   .5000   .6000   .7000
  .0092   .0110   .0140   .0182   .0243   .3000   .4000   .5000   .6000   .7000
  .0104   .0127   .0168   .0221   .0296   .3000   .4000   .5000   .6000   .7000

                                   SET #2
                                   ======
  .0309   .0336   .0373   .0430   .0508   .3000   .4000   .5000   .6000   .7000
  .0272   .0290   .0320   .0362   .0423   .3000   .4000   .5000   .6000   .7000
  .0250   .0263   .0282   .0313   .0360   .3000   .4000   .5000   .6000   .7000
  .0230   .0239   .0253   .0280   .0310   .3000   .4000   .5000   .6000   .7000
  .0211   .0220   .0234   .0261   .0296   .3000   .4000   .5000   .6000   .7000
  .0212   .0222   .0236   .0264   .0299   .3000   .4000   .5000   .6000   .7000
  .0214   .0226   .0241   .0269   .0306   .3000   .4000   .5000   .6000   .7000
  .0218   .0231   .0248   .0278   .0317   .3000   .4000   .5000   .6000   .7000
```

Figure 16. Examp.dat input breakdown (cont'd).

```
************************************ COLUMN ************************************
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

                                SET #2 (CONT'D)
                                ===============
  .0233    .0248    .0270    .0303    .0347    .3000    .4000    .5000    .6000    .7000
  .0272    .0290    .0320    .0362    .0423    .3000    .4000    .5000    .6000    .7000
  .0294    .0317    .0358    .0441    .0486    .3000    .4000    .5000    .6000    .7000

                                    SET #3
                                    ======
                                                                               -2.0
   .0                                                                            .05
   .0                                                                            .03
   .0
   .0
   .0
   .0
   .0
   .0
   .0
   .0
   .0

                    CALCULATION STATION AND BLADE ROW DATA
                    ======================================
   AA           ZTIP        ZHUB        BT          BH         BLEED
   ==           ====        ====        ==          ==         =====
ANNULAR      -32.0000    -32.0000      .0000       .0000       .0000
ANNULAR      -21.0000    -21.0000      .0000       .0000       .0000
ANNULAR      -13.0000    -13.0000      .0000       .0000       .0000
ANNULAR       -7.0000     -7.0000      .0000       .0020       .0000
ANNULAR       -3.0000     -3.0000      .0030       .0030       .0000

   AA           ZTIP        ZHUB       BT(LE)      BH(LE)    BLEED(LE)
   ==           ====        ====       ======      ======    =========
ROTOR          2.0500      2.0500      .0070       .0070       .0000

     DLIM      ALIM       BT(TE)     BH(TE)   BLEED(TE)   CRENGY     BMATL      NXCUT
     ====      ====       ======     ======   =========   ======     =====      =====
    .4600   -20.0000      .0100      .0100      .0000     1.0000     7.823          0

   ILOSS    OP        AA   AB   BB        CC        DD       EE   EB        CHOKE
   =====    ==        ==   ==   ==        ==        ==       ==   ==        =====
     1     COORD   TABLE  SS  TABLE     TABLE     TABLE    TABLE  LE        .0000
```

Figure 17. Examp.dat input breakdown (cont'd).

```
*********************************** COLUMN ***********************************
          1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

 # BLADES  SOLIDITY    TILT      PRA       PRB       PRC       PRD       PRE
 ========  ========    ====      ===       ===       ===       ===       ===
 44.0000   1.3000      .0000     .0000     .0000     .0000     .0000     .0000

    TALE      TBLE      TCLE      TDLE      TATE      TBTE      TCTE      TDTE
    ====      ====      ====      ====      ====      ====      ====      ====
   .0055     .0000     .0000    0.0000     .0055     .0000     .0000    0.0000

   TAMAX     TBMAX     TCMAX     TDMAX    CHORDA    CHORDB    CHORDC      IDEF
   =====     =====     =====     =====    ======    ======    ======      ====
   .0327     .0496     .0000    0.0000     .0000     .0000     .0000         0

                    INCIDENCE ANGLE ARRAY ON STREAMLINES
                    ====================================
   .00       .00       .00       .00       .00       .00       .00       .00
   .00       .00       .00

                    DEVIATION ANGLE ARRAY ON STREAMLINES
                    ====================================
  5.40      4.40      2.90      2.60      2.80      2.90      2.90      3.00
  3.60      6.20      7.80

              INLET/OUTLET SEGMENT TURNING RATE ON STREAMLINES
              ================================================
  0.00      0.25      0.50      0.75      1.00      1.00      1.000     1.00
  1.000     1.000     1.000

                  TRANSITION POINT LOCATION ON STREAMLINES
                  ========================================
  0.700     0.680     0.660     0.640     0.620     0.600     0.540     0.480
  0.420     0.360     0.300

             MAXIMUM THICKNESS POINT LOCATION ON STREAMLINES
             ===============================================
  0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500
  0.5000    0.5000    0.5000

 AA           ZTIP      ZHUB      BT(LE)    BH(LE)    BLEED(LE)
 ==           ====      ====      ======    ======    =========
 STATOR      9.4000    9.4000     .0100     .0100      .0000
```

Figure 18. Examp.dat input breakdown (cont'd).

```
*********************************** COLUMN ***********************************
          1111111111222222222233333333334444444444555555555566666666667777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

  DLIM     ALIM      BT(TE)     BH(TE)     BLEED(TE)                      NXCUT
  ====     ====      ======     ======     =========                      =====
 .7000    1.0000     .0100      .0100       .0000                             0

ILOSS     OP        AA    AB    BB        CC         DD         EE    EB    CHOKE

=====     ==        ==    ==    ==        ==         ==         ==    ==    =====
  2     COORD     TABLE   SS  TABLE     TABLE      SHOCK      TABLE   LE    .0000

# BLADES  SOLIDITY    TILT       PRA        PRB        PRC        PRD        PRE
========  ========    ====       ===        ===        ===        ===        ===
 48.0000   1.2700     .0000      .0000      .0000      .0000      .0000      .0000

   TALE      TBLE      TCLE       TDLE       TATE       TBTE       TCTE       TDTE
   ====      ====      ====       ====       ====       ====       ====       ====
  .0061     0.0080     .0000      .0000      .0061     0.0000      .0000      .0000

  TAMAX     TBMAX     TCMAX      TDMAX      CHORDA     CHORDB     CHORDC     IDEF
  =====     =====     =====      =====      ======     ======     ======     ====
  .0667     0.0200     .0000      .0000      .0000      .0000      .0000        0

                    INCIDENCE ANGLE ARRAY ON STREAMLINES
                    ====================================
  0.00      0.00      0.00       0.00       0.00       0.00       0.00       0.00
  0.00      0.00      0.00

                    DEVIATION ANGLE ARRAY ON STREAMLINES
                    ====================================
 14.20     11.10      9.40       8.90       8.80       8.80       8.80       8.70
  8.70      8.80      9.10

              INLET/OUTLET SEGMENT TURNING RATE ON STREAMLINES
              ================================================
  0.50      0.50      0.50       0.50       0.50       0.50       0.50       0.50
  0.50      0.50      0.50

                   TRANSITION POINT LOCATION ON STREAMLINES
                   ========================================
   .50       .50       .50        .50        .50        .50        .50        .50
   .50       .50       .50

  AA        ZTIP      ZHUB        BT         BH        BLEED
  ==        ====      ====        ==         ==        =====
ANNULAR   14.0000   14.0000     .0150      .0150      .0000
ANNULAR   18.0000   18.0000     .0150      .0150      .0000
ANNULAR   23.0000   23.0000     .0150      .0150      .0000
```

Figure 19. Examp.dat input breakdown (cont'd).

```
                         Input Data Field for the Program AXIDES
                               (General or Overall Data)
               |T|                                                                                  |
               |y|******************************* Column *******************************|
   Option      |p|         11111111112222222222333333333344444444445555555555666666666677777777778|     Format
               |e|12345678901234567890123456789012345678901234567890123456789012345678901234567890|
------------------------------------------------------------------------------------------------------------------
               |G|                  TITLE(K), K=1,18                                      ITG IBR| 18A4, 2I4
               |G|NSTRM NROW  NA NLOSS NTIP NHUB    ROT       FLOW    PRATIO   MOLWT    SCALEF | 6I5, 5F10.4
               |G|                  (CP(K),K=1,3)                                          LUNITI| 3E20.8, 10X, I10
               |G|                  (CP(K),K=4,6)                                          LUNITO| 3E20.8, 10X, I10
               |G|  (Cumulatative Flow Frac. From Tip @ Streamlines)      (FLO(K),K=2,NSTRM) | 8F10.4
IF NSTRM>9     |G|                                                        (FLO(K),K=10,NSTRM)| 8F10.4
               |G|  (Inlet Total Temp. @ Streamlines)   (TO(1,J),J=1,NSTRM)                  | 8F10.4
IF NSTRM>8     |G|                                      (TO(1,J),J=9,NSTRM)                  | 8F10.4
               |G|  (Inlet Total Press. @ Streamlines)  (PO(1,J),J=1,NSTRM)                  | 8F10.4
IF NSTRM>8     |G|                                      (PO(1,J),J=9,NSTRM)                  | 8F10.4
               |G|  (Inlet Tang. Vel. @ Streamlines)    (VTH(1,J),J=1,NSTRM)                 | 8F10.4
IF NSTRM>8     |G|                                      (VTH(1,J),J=9,NSTRM)                 | 8F10.4
               |G|  (Axial Coord. of Casing Wall Pts.)  (XTIP(I),I=1,NTIP)                   | 8F10.4
   IF NTIP>8   |G|                                      (XTIP(I),I=9,NTIP)                   | 8F10.4
   IF NTIP>16  |G|                                      (XTIP(I),I=17,NTIP)                  | 8F10.4
   IF NTIP>24  |G|                                      (XTIP(I),I=25,NTIP)                  | 8F10.4
   IF NTIP>32  |G|                                      (XTIP(I),I=33,NTIP)                  | 8F10.4
               |G|  (Radial Coord. of Casing Wall Pts.) (RTIP(I),I=1,NTIP)                   | 8F10.4
   IF NTIP>8   |G|                                      (RTIP(I),I=9,NTIP)                   | 8F10.4
   IF NTIP>16  |G|                                      (RTIP(I),I=17,NTIP)                  | 8F10.4
   IF NTIP>24  |G|                                      (RTIP(I),I=25,NTIP)                  | 8F10.4
   IF NTIP>32  |G|                                      (RTIP(I),I=33,NTIP)                  | 8F10.4
               |G|  (Axial Coord. of Hub Wall Pts.)     (XHUB(I),I=1,NTIP)                   | 8F10.4
   IF NHUB>8   |G|                                      (XHUB(I),I=9,NTIP)                   | 8F10.4
   IF NHUB>16  |G|                                      (XHUB(I),I=17,NTIP)                  | 8F10.4
   IF NHUB>24  |G|                                      (XHUB(I),I=25,NTIP)                  | 8F10.4
   IF NHUB>32  |G|                                      (XHUB(I),I=33,NTIP)                  | 8F10.4
               |G|  (Radial Coord. of Hub Wall Pts.)    (RHUB(I),I=1,NTIP)                   | 8F10.4
   IF NHUB>8   |G|                                      (RHUB(I),I=9,NTIP)                   | 8F10.4
   IF NHUB>16  |G|                                      (RHUB(I),I=17,NTIP)                  | 8F10.4
   IF NHUB>24  |G|                                      (RHUB(I),I=25,NTIP)                  | 8F10.4
   IF NHUB>32  |G|                                      (RHUB(I),I=33,NTIP)                  | 8F10.4
IF NLOSS>0, J=1 |G| (Loss Parameter) (DLOS(K,J,1),K=1,5) (Dfactor Array) (DFTAB(K,J,1),K=1,5)| 10F8.4
            J=2 |G|                  (DLOS(K,J,1),K=1,5)                 (DFTAB(K,J,1),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,1),K=1,5)                 (DFTAB(K,J,1),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,1),K=1,5)                 (DFTAB(K,J,1),K=1,5)| 10F8.4
        J=NSTRM |G|                  (DLOS(K,J,1),K=1,5)                 (DFTAB(K,J,1),K=1,5)| 10F8.4
IF NLOSS>1, J=1 |G| (Loss Parameter) (DLOS(K,J,2),K=1,5) (Dfactor Array) (DFTAB(K,J,2),K=1,5)| 10F8.4
            J=2 |G|                  (DLOS(K,J,2),K=1,5)                 (DFTAB(K,J,2),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,2),K=1,5)                 (DFTAB(K,J,2),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,2),K=1,5)                 (DFTAB(K,J,2),K=1,5)| 10F8.4
        J=NSTRM |G|                  (DLOS(K,J,2),K=1,5)                 (DFTAB(K,J,2),K=1,5)| 10F8.4
IF NLOSS>2, J=1 |G| (Loss Parameter) (DLOS(K,J,3),K=1,5) (Dfactor Array) (DFTAB(K,J,3),K=1,5)| 10F8.4
            J=2 |G|                  (DLOS(K,J,3),K=1,5)                 (DFTAB(K,J,3),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,3),K=1,5)                 (DFTAB(K,J,3),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,3),K=1,5)                 (DFTAB(K,J,3),K=1,5)| 10F8.4
        J=NSTRM |G|                  (DLOS(K,J,3),K=1,5)                 (DFTAB(K,J,3),K=1,5)| 10F8.4
IF NLOSS>3, J=1 |G| (Loss Parameter) (DLOS(K,J,4),K=1,5) (Dfactor Array) (DFTAB(K,J,4),K=1,5)| 10F8.4
            J=2 |G|                  (DLOS(K,J,4),K=1,5)                 (DFTAB(K,J,4),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,4),K=1,5)                 (DFTAB(K,J,4),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,4),K=1,5)                 (DFTAB(K,J,4),K=1,5)| 10F8.4
        J=NSTRM |G|                  (DLOS(K,J,4),K=1,5)                 (DFTAB(K,J,4),K=1,5)| 10F8.4
IF NLOSS>4, J=1 |G| (Loss Parameter) (DLOS(K,J,5),K=1,5) (Dfactor Array) (DFTAB(K,J,5),K=1,5)| 10F8.4
            J=2 |G|                  (DLOS(K,J,5),K=1,5)                 (DFTAB(K,J,5),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,5),K=1,5)                 (DFTAB(K,J,5),K=1,5)| 10F8.4
              . |G|                  (DLOS(K,J,5),K=1,5)                 (DFTAB(K,J,5),K=1,5)| 10F8.4
        J=NSTRM |G|                  (DLOS(K,J,5),K=1,5)                 (DFTAB(K,J,5),K=1,5)| 10F8.4
```

Figure 20. General input data field format.

Input Data Field for the Program AXIDES
(Data for Annular Stations & Rotors)

```
                |T|                                                                                |
                |y|*********************************** Column **********************************|
     Option     |p|         1111111111222222222233333333334444444444555555555566666666667777777778|   Format
                |e|12345678901234567890123456789012345678901234567890123456789012345678901234567890|
----------------------------------------------------------------------------------------------------------------
                |A| AA          ZTIP(1)   ZHUB(1)     BT(1)     BH(1)  BLEED(1)                  | A4,6X,5F10.4
                |A| AA          ZTIP(2)   ZHUB(2)     BT(2)     BH(2)  BLEED(2)                  | A4,6X,5F10.4
                |A| AA          ZTIP(3)   ZHUB(3)     BT(3)     BH(3)  BLEED(3)                  | A4,6X,5F10.4
                |A| AA          ZTIP(4)   ZHUB(4)     BT(4)     BH(4)  BLEED(4)                  | A4,6X,5F10.4
----------------------------------------------------------------------------------------------------------------
                |R| AA      ZTIP(INAB) ZHUB(INAB)     BT(I)     BH(I)  BLEED(I)                  | A4,6X,5F10.4
                |R| DLIM(IRW) ALIM(IRW)     BT(I)     BH(1) BLEED(I) CRENGY(IR)BMATL(IR) NXCUT(IRW)| 7F10.7,I10
                |R|ILOSS  OPM  OP   OPO  AA  AB    BB        CC        DD        EE  EB  CHOKE(IRW)| I5,1X,2A4,2x,3(A4,
                |R|BLADES(IRW) SOLID(IRW) TILT(IRW) PRA(IRW) PRB(IRW)  PRC(IRW)  PRD(IRW)  PRE(IRW)| 8F10.4
IF ILOSS(IROW)>=0|R|  PTT(IRW)          (PTC(J,IRW),J=1,5)                                       | 6F10.4
                |R| TALE(IRW) TBLE(IRW) TCLE(IRW) TDLE(IRW) TATE(IRW) TBTE(IRW) TCTE(IRW) TDTE(IRW)| 8F10.4
                |R| TAMAX( )  TBMAX( )  TCMAX( )  TDMAX( )  CHORDA( ) CHORDB( ) CHORDC( ) IDEF(IRW)| 7F10.4,I10
IF IDEF(IROW)#0 |R|          (ACF(J,IROW),J=1,4)                  (BCF(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (CCF(J,IROW),J=1,4)                  (DCF(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (ACR(J,IROW),J=1,4)                  (BCR(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (CCR(J,IROW),J=1,4)                  (DCR(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (ELE(J,IROW),J=1,4)                  (ETE(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (ATF(J,IROW),J=1,4)                  (BTF(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (CTF(J,IROW),J=1,4)                  (DTF(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (ATR(J,IROW),J=1,4)                  (BTR(J,IROW),J=1,4)           | 8F10.6
IF IDEF(IROW)#0 |R|          (CTR(J,IROW),J=1,4)                  (DTR(J,IROW),J=1,4)           | 8F10.6
IF AA=TABLE     |R|   (Incidence Angle Array on Streamlines)      (INC(IROW,J),J=1,NSTRM)       | 8F10.4
    IF NSTRM>8  |R|                                               (INC(IROW,J),J=9,NSTRM)       | 8F10.4
IF BB=TABLE     |R|   (Deviation Angle Array on Streamlines)      (DEV(IROW,J),J=1,NSTRM)       | 8F10.4
    IF NSTRM>8  |R|                                               (DEV(IROW,J),J=9,NSTRM)       | 8F10.4
IF CC=TABLE     |R|   (Inlet/Outlet Segment Turning Rate)         (PHI(IROW,J),J=1,NSTRM)       | 8F10.4
    IF NSTRM>8  |R|                                               (PHI(IROW,J),J=9,NSTRM)       | 8F10.4
IF DD=TABLE     |R|   (Trans. Point Location)                     (TRANS(IROW,J),J=1,NSTRM)     | 8F10.4
    IF NSTRM>8  |R|                                               (TRANS(IROW,J),J=9,NSTRM)     | 8F10.4
IF EE=TABLE     |R|   (Max. Thickness Point Location)             (ZMAX(IROW,J),J=1,NSTRM)      | 8F10.4
    IF NSTRM>8  |R|                                               (ZMAX(IROW,J),J=9,NSTRM)      | 8F10.4
IF OP=VEL.DIA.  |R|          (ZTEMP(I-1,J),J=1,5)                 (RTEMP(I-1,J),J=1,5)          | 10F8.4
IF OP=VEL.DIA.  |R|          (ZTEMP(I,J),J=1,5)                   (RTEMP(I,J),J=1,5)            | 10F8.4
----------------------------------------------------------------------------------------------------------------
```

Figure 21. General input data field (cont'd).

```
                     Input Data Field for the Program AXIDES
                     (Data for Stators & Annular Stations)

                 |T|
                 |y|********************************** Column **********************************|
      Option     |p|         111111111122222222223333333333444444444455555555556666666666777777777|     Format
                 |e|12345678901234567890123456789012345678901234567890123456789012345678901234567890|
------------------------------------------------------------------------------------------------------------
                 |S| AA      ZTIP(INAB) ZHUB(INAB)    BT(I)     BH(I)  BLEED(I)                     | A4,6X,5F10.4
                 |S| DLIM(IRW) ALIM(IRW)     BT(I)     BH(I) BLEED(I)                    NXCUT(IRW)| 7F10.7,I10
                 |S|ILOSS  OPH  OP   OPO  AA  AB    BB       CC        DD       EE  EB  CHOKE(IRW)| I5,1X,2A4,2x,3(A4,
                 |S|BLADES(IRW) SOLID(IRW) TILT(IRW) PRA(IRW) PRB(IRW)  PRC(IRW)  PRD(IRW)  PRE(IRW)| 8F10.3
IF ILOSS(IROW)>=0|S|  PTT(IRW)          (PTC(J,IRW),J=1,5)                                         | 6F10.4
                 |S| TALE(IRW) TBLE(IRW) TCLE(IRW) TDLE(IRW) TATE(IRW) TBTE(IRW) TCTE(IRW) TDTE(IRW)| 8F10.4
                 |S| TAMAX( )  TBMAX( )  TCMAX( )  TDMAX( )  CHORDA( ) CHORDB( ) CHORDC( ) IDEF(IRW)| 7F10.4,I10
IF IDEF(IROW)#0  |S|        (ACF(J,IROW),J=1,4)                (BCF(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (CCF(J,IROW),J=1,4)                (DCF(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (ACR(J,IROW),J=1,4)                (BCR(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (CCR(J,IROW),J=1,4)                (DCR(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (ELE(J,IROW),J=1,4)                (ETE(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (ATF(J,IROW),J=1,4)                (BTF(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (CTF(J,IROW),J=1,4)                (DTF(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (ATR(J,IROW),J=1,4)                (BTR(J,IROW),J=1,4)             | 8F10.6
IF IDEF(IROW)#0  |S|        (CTR(J,IROW),J=1,4)                (DTR(J,IROW),J=1,4)             | 8F10.6
IF AA=TABLE      |S|  (Incidence Angle Array on Streamlines)   (INC(IROW,J),J=1,NSTRM)        | 8F10.4
    IF NSTRM>8   |S|                                           (INC(IROW,J),J=9,NSTRM)        | 8F10.4
IF BB=TABLE      |S|  (Deviation Angle Array on Streamlines)   (DEV(IROW,J),J=1,NSTRM)        | 8F10.4
    IF NSTRM>8   |S|                                           (DEV(IROW,J),J=9,NSTRM)        | 8F10.4
IF CC=TABLE      |S|  (Inlet/Outlet Segment Turning Rate)      (PHI(IROW,J),J=1,NSTRM)        | 8F10.4
    IF NSTRM>8   |S|                                           (PHI(IROW,J),J=9,NSTRM)        | 8F10.4
IF DD=TABLE      |S|  (Trans. Point Location)                  (TRANS(IROW,J),J=1,NSTRM)      | 8F10.4
    IF NSTRM>8   |S|                                           (TRANS(IROW,J),J=9,NSTRM)      | 8F10.4
IF EE=TABLE      |S|  (Max. Thickness Point Location)          (ZMAX(IROW,J),J=1,NSTRM)       | 8F10.4
    IF NSTRM>8   |S|                                           (ZMAX(IROW,J),J=9,NSTRM)       | 8F10.4
IF OP=VEL.DIA.   |S|       (ZTEMP(I-1,J),J=1,5)                (RTEMP(I-1,J),J=1,5)           | 10F8.4
IF OP=VEL.DIA.   |S|       (ZTEMP(I,J),J=1,5)                  (RTEMP(I,J),J=1,5)             | 10F8.4
------------------------------------------------------------------------------------------------------------
                 |.|
                 |.|
                 |.|
                 |.|
------------------------------------------------------------------------------------------------------------
                 |A| AA        ZTIP(I)    ZHUB(I)     BT(I)     BH(I)  BLEED(I)                   | A4,6X,5F10.4
                 |A| AA        ZTIP(I)    ZHUB(I)     BT(I)     BH(I)  BLEED(I)                   | A4,6X,5F10.4
                 |A| AA        ZTIP(I)    ZHUB(I)     BT(I)     BH(I)  BLEED(I)                   | A4,6X,5F10.4
------------------------------------------------------------------------------------------------------------
IF NXCUT(IROW)<0 |C|  (Radial Location of Blade Sections)      (XCUT(J),J=1,NC)               | 8F10.4
    IF NC>8      |C|                                           (XCUT(J),J=9,NC)               | 8F10.4
    IF NC>16     |C|                                           (XCUT(J),J=17,NC)              | 8F10.4
                 |.|
                 |.|
                 |.|
                 |.|
```

Figure 22. General input data field (cont'd).

APPENDIX B. AXIDES OUTPUT

This appendix contains the output file Examp.out, associated with input file Examp.dat. The input file is the example provided with the code when it was purchased and was the first to be successfully run on the AA Department workstations.

1

*** INPUT DATA FOR COMPRESSOR DESIGN PROGRAM ***

First Stage Redesign of NASA 2 Stage - AR = 1.52

Scale Factor is 1.0000

The Compressor Rotational Speed is 16100.0 Rpm.

The Desired Compressor Pressure Ratio is 1.574 .

Calculations Will be Performed on 11 Streamlines.

The Inlet Flow Rate is 29.484 (Kg/Sec)

The Molecular Weight is 28.97

The Compressor Has 2 Blade Rows.

Calculations Will Be Made at The Blade Edges And at. 8 Annular Stations.

The Specific Heat Polynomial is in The Following Form

Cp = 0.23762E+00 + 0.39557E-04*T + -0.28463E-06*T**2 + 0.81651E-09*T**3 + -0.81994E-12*T**4 + 0.29443E-15*T**5

INPUT DISTRIBUTIONS BY STREAMLINE OR STREAMTUBE

Streamline No.	Inlet Total Temperature (Deg. K.)	Inlet Total Pressure (Kg/sq M)	Inlet Whirl Velocity (M/Sec)	Streamtube No.	Streamtube Flow Fraction
1	288.170	10130.0	0.000	1	0.1257
2	288.170	10130.0	0.000	2	0.2457
3	288.170	10130.0	0.000	3	0.3600
4	288.170	10130.0	0.000	4	0.4686
5	288.170	10130.0	0.000	5	0.5714
6	288.170	10130.0	0.000	6	0.6686
7	288.170	10130.0	0.000	7	0.7600
8	288.170	10130.0	0.000	8	0.8457
9	288.170	10130.0	0.000	9	0.9257
10	288.170	10130.0	0.000	10	1.0000
11	288.170	10130.0	0.000		

1

INPUT DATA POINTS FOR TIP AND HUB CONTOURS.

Tip Axial Coordinate (Cm)	Tip Radius (Cm)	Hub Axial Coordinate (Cm)	Hub Radius (Cm)
-35.560	25.400	-35.560	7.302
-30.480	25.400	-30.480	7.302
-25.400	25.400	-25.400	7.493

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-20.320	25.400	-20.320	9.255
-15.240	25.400	-15.240	9.144
-12.700	25.400	-12.700	9.589
-10.160	25.400	-10.160	10.096
-7.620	25.400	-7.620	10.515
-5.080	25.400	-5.080	11.049
-2.540	25.400	-2.540	[illegible]
0.000	25.390	0.000	12.668
4.064	25.146	4.064	[illegible]
5.080	25.146	5.080	14.336
7.620	25.146	7.620	14.732
10.973	25.146	10.973	15.240
12.700	25.146	12.700	15.240
15.240	25.146	15.240	15.240
17.780	25.146	17.780	15.240
20.320	25.146	20.320	15.240
24.000	25.146	24.000	[illegible]

1 WARNING ONLY. At Input Point, 13, The Hub Contour Data is Not Very Smooth.

THE INPUT PROFILE LOSS TABLES - OMEGA(Bar)*COS(Beta)/(2.0*Sigma)

** PROFILE LOSS TABLE NO. 1 **

Pct. Pass	D-Factor	Loss Param.	D-Factor	Loss Param.	D-Factor	Loss Param	D-Factor	Loss Param	D-Factor	Loss Param
0.00	0.3000	0.0167	0.4000	0.0199	0.5000	0.0243	0.6000	0.0312	0.7000	0.0406
10.00	0.3000	0.0123	0.4000	0.0143	0.5000	0.0176	0.6000	0.0222	0.7000	0.0289
20.00	0.3000	0.0100	0.4000	0.0113	0.5000	0.0132	0.6000	0.0163	0.7000	0.0210
30.00	0.3000	0.0080	0.4000	0.0089	0.5000	0.0103	0.6000	0.0130	0.7000	[illegible]
40.00	0.3000	0.0080	0.4000	0.0089	0.5000	0.0103	0.6000	0.0130	0.7000	[illegible]
50.00	0.3000	0.0080	0.4000	0.0089	0.5000	0.0103	0.6000	0.0130	0.7000	0.0165
60.00	0.3000	0.0080	0.4000	0.0089	0.5000	0.0103	0.6000	0.0130	0.7000	0.0165
70.00	0.3000	0.0080	0.4000	0.0089	0.5000	0.0103	0.6000	0.0130	0.7000	0.0165
80.00	0.3000	0.0090	0.4000	0.0103	0.5000	0.0122	0.6000	0.0153	0.7000	[illegible]
90.00	0.3000	0.0092	0.4000	0.0110	0.5000	0.0140	0.6000	0.0182	0.7000	0.0243
100.00	0.3000	0.0104	0.4000	0.0127	0.5000	0.0168	0.6000	0.0221	0.7000	0.0296

** PROFILE LOSS TABLE NO. 2 **

Pct. Pass.	D-Factor	Loss Param.	D-Factor	Loss Param.	D-Factor	Loss Param.	D-Factor	Loss Param	D-Factor	Loss Param
0.00	0.3000	0.0309	0.4000	0.0336	0.5000	0.0373	0.6000	0.0430	0.7000	0.0509
10.00	0.3000	0.0272	0.4000	0.0290	0.5000	0.0320	0.6000	0.0362	0.7000	[illegible]
20.00	0.3000	0.0250	0.4000	0.0263	0.5000	0.0282	0.6000	0.0313	0.7000	[illegible]
30.00	0.3000	0.0230	0.4000	0.0239	0.5000	0.0253	0.6000	0.0280	0.7000	[illegible]
40.00	0.3000	0.0211	0.4000	0.0220	0.5000	0.0234	0.6000	0.0261	0.7000	0.0296
50.00	0.3000	0.0212	0.4000	0.0222	0.5000	0.0236	0.6000	0.0264	0.7000	0.0299
60.00	0.3000	0.0214	0.4000	0.0226	0.5000	0.0241	0.6000	0.0269	0.7000	0.0306
70.00	0.3000	0.0218	0.4000	0.0231	0.5000	0.0248	0.6000	0.0278	0.7000	0.0317
80.00	0.3000	0.0233	0.4000	0.0248	0.5000	0.0270	0.6000	0.0303	0.7000	0.0347
90.00	0.3000	0.0272	0.4000	0.0290	0.5000	0.0320	0.6000	0.0362	0.7000	0.0423
100.00	0.3000	0.0294	0.4000	0.0317	0.5000	0.0358	0.6000	0.0441	0.7000	0.0496

** LOSS SET No. 3 is The Analytical Method by ROBERTS For Profile And Secondary Losses **

1 The Input Clearances Are 0.0500 (Cm) For The Rotor Tip And 0.0300 (Cm) For The Stator Hub.

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*** PRINTOUT OF INPUT STATION DATA ***

** INPUT SET NO. 1 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
-32.0000	-32.0000	0.0000	0.0000	0.0000

** INPUT SET NO. 2 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
-21.0000	-21.0000	0.0000	0.0000	0.0000

** INPUT SET NO. 3 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
-13.0000	-13.0000	0.0000	0.0000	0.0000

** INPUT SET NO. 4 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
-7.0000	-7.0000	0.0000	0.0020	0.0000

** INPUT SET NO. 5 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
-3.0000	-3.0000	0.0030	0.0030	0.0000

1 PAGE NO. 5

*** PRINTOUT OF INPUT STATION DATA ***

** INPUT SET NO. 6 IS ROTOR NO. 1 **

* FOR THIS BLADE ROW THE INPUT OPTION IS COORD.

TIP C.G. AXIAL LOCATION (Cm)	HUB C.G. AXIAL LOCATION (Cm)	INLET TIP BLOCKAGE	INLET HUB BLOCKAGE	INLET MASS BLEED
2.0500	2.0500	0.0070	0.0070	0.0000

LOSS SET USED	BLADE TILT ANGLE (Degrees)	OUTLET TIP BLOCKAGE	OUTLET HUB BLOCKAGE	OUTLET MASS BLEED
1	0.0000	0.0100	0.0100	0.0000

TIP D FACTOR LIMIT	HUB FLOW ANGLE LIMIT (Degrees)	TIP SOLIDITY	NUMBER OF BLADES	CUM ENERGY ADD FRACT.
0.4600	-20.0000	1.3000	44	1.0000

* POLYNOMIAL COEFS. FOR RADIAL PROFILES OF A BLADE AERO. PARAMETER AND BASIC BLADE ELEMENT GEOMETRY PARAMETERS *

COEF.	ROTOR OUTLET PRESSURE	L.E. RADIUS/CHORD	T.E. RADIUS/CHORD	MAX. THICKNESS CHORD	CHORD/TIP CHORD
CONSTANT		0.0055	0.0055	0.0327	
LINEAR	0.0000	0.0000	0.0000	0.0496	0.0000
QUADRATIC	0.0000	0.0000	0.0000	0.0000	0.0000
CUBIC	0.0000	0.0000	0.0000	0.0000	0.0000
QUARTIC	0.0000				
QUINTIC	0.0000				

* INPUT BLADE ELEMENT DEFINITION OPTIONS *

INCIDENCE ANGLE	DEVIATION ANGLE	TURNING RATE RATIO	TRANSITION POINT	MAX. THICKNESS POINT	CHOKE MARGIN	BLADE MATERIAL DENSITY (Gm/(cm)**3)
TABLE (S.S.REF.)	TABLE	TABLE	TABLE	TABLE (L.E. REF.)	NONE	7.82100

* TABLE OF BLADE SECTION DESIGN VARIABLES INPUT *

(VARIABLES CONTROLLED BY OTHER OPTIONS WILL APPEAR AS ZEROS IN THE TABLE.)

STREAMLINE NUMBER	SUCTION SURFACE INCIDENCE ANGLE (DEGREES)	DEVIATION ANGLE (DEGREES)	INLET/OUTLET TURNING RATE RATIO	TRANSITION/CHORD LOCATION	MAX. THICKNESS LOCATION/CHORD
1	0.0000	5.4000	0.0000	0.7000	0.5000
2	0.0000	4.4000	0.2500	0.6800	0.5000
3	0.0000	2.9000	0.5000	0.6600	0.5000
4	0.0000	2.6000	0.7500	0.6400	0.5000
5	0.0000	2.8000	1.0000	0.6200	0.5000
6	0.0000	2.9000	1.0000	0.6000	0.5000
7	0.0000	2.9000	1.0000	0.5400	0.5000
8	0.0000	3.0000	1.0000	0.4800	0.5000
9	0.0000	3.6000	1.0000	0.4200	0.5000
10	0.0000	6.2000	1.0000	0.3600	0.5000
11	0.0000	7.8000	1.0000	0.3000	0.5000

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*** PRINTOUT OF INPUT STATION DATA ***

PAGE N

** INPUT SET NO. 7 IS A GUIDE VANE OR STATOR**

* FOR THIS BLADE ROW THE INPUT OPTION IS COORD.

TIP C.G. AXIAL LOCATION (Cm)	HUB C.G. AXIAL LOCATION (Cm)	INLET TIP BLOCKAGE	INLET HUB BLOCKAGE	INLET MASS BLEED
9.4000	9.4000	0.0100	0.0100	0.0000

LOSS SET USED	BLADE TILT ANGLE (Degrees)	OUTLET TIP BLOCKAGE	OUTLET HUB BLOCKAGE	OUTLET MASS BLEED
2	0.0000	0.0100	0.0100	0.0000

HUB D FACTOR LIMIT	INLET HUB MACH LIMIT	TIP SOLIDITY	NUMBER OF BLADES
0.7000	1.0000	1.2700	48

* POLYNOMIAL COEFS. FOR RADIAL PROFILES OF A BLADE AERO. PARAMETER AND BASIC BLADE ELEMENT GEOMETRY PARAMETERS *

COEF.	STATOR OUTLET V(0)	L.E. RADIUS/CHORD	T.E. RADIUS CHORD	MAX. THICKNESS CHORD	CHORD TIP CHORD
INV.SQ.	0.00				
INVERSE	0.00				
CONSTANT	0.00	0.0061	0.0061	0.0667	0.0000
LINEAR	0.00	0.0080	0.0000	0.0200	0.0000
QUADRATIC	0.00	0.0000	0.0000	0.0000	[illegible]
CUBIC		0.0000	0.0000	0.0000	

* INPUT BLADE ELEMENT DEFINITION OPTIONS *

INCIDENCE ANGLE	DEVIATION ANGLE	TURNING RATE RATIO	TRANSITION POINT	MAX. THICKNESS POINT	CHOKE MARGIN
TABLE (S.S.REF.)	TABLE	TABLE	S.S. SHOCK	TABLE (L.E. REF.)	NONE

* TABLE OF BLADE SECTION DESIGN VARIABLES INPUT *

(VARIABLES CONTROLLED BY OTHER OPTIONS WILL APPEAR AS ZEROS IN THE TABLE)

STREAMLINE NUMBER	SUCTION SURFACE INCIDENCE ANGLE (DEGREES)	DEVIATION ANGLE (DEGREES)	INLET/OUTLET TURNING RATE RATIO	TRANSITION/CHORD LOCATION	MAX. THICKNESS LOCATION/CHORD
1	0.0000	14.2000	0.5000	0.0000	0.5000
2	0.0000	11.1000	0.5000	0.0000	0.5000
3	0.0000	9.4000	0.5000	0.0000	0.5000
4	0.0000	8.9000	0.5000	0.0000	0.5000
5	0.0000	8.8000	0.5000	0.0000	0.5000
6	0.0000	8.8000	0.5000	0.0000	0.5000
7	0.0000	8.8000	0.5000	0.0000	0.5000
8	0.0000	8.7000	0.5000	0.0000	0.5000
9	0.0000	8.7000	0.5000	0.0000	0.5000
10	0.0000	8.8000	0.5000	0.0000	0.5000
11	0.0000	9.1000	0.5000	0.0000	0.5000

PAGE N

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*** PRINTOUT OF INPUT STATION DATA ***

** INPUT SET NO. 8 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
14.0000	14.0000	0.0150	0.0150	0.0000

** INPUT SET NO. 9 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
18.0000	18.0000	0.0150	0.0150	0.0000

** INPUT SET NO. 10 IS AN ANNULAR STATION **

TIP AXIAL LOCATION (Cm)	HUB AXIAL LOCATION (Cm)	TIP BLOCKAGE FACTOR	HUB BLOCKAGE FACTOR	MASS BLEED FRACTION
23.0000	23.0000	0.0150	0.0150	0.0000

I	Ift	Z(Ift,JM) (Cm)	AR	I	Z(I,J) (Cm)	AR
1	1	-32.0000	0.0000	1	-32.0000	0.0000
2	2	-21.0000	1.5696	2	-21.0000	1.5696
3	3	-13.0000	1.9835	3	-13.0000	1.9835
4	4	-7.0000	2.4531	4	-7.0000	2.4531
5	5	-3.0000	3.4246	5	-3.0000	3.4246
6	6	0.4150	3.6378	6	0.4150	3.6378
7	7	3.9247	3.1056	7	3.9247	3.1056
8	8	7.7701	2.6431	8	7.7701	2.6431
9	9	11.3647	2.6931	9	11.3647	2.6931
10	10	14.0000	3.6421	10	14.0000	3.6421
11	11	18.0000	2.3978	11	18.0000	2.3978
12	12	23.0000	1.9181	12	23.0000	1.9181

Fact1 = 2.3777 Fact2 = 4.5924

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
1	0.23968	1.40064	0.000	0.0	17.2239	19.303	0.0000	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	STREAMLINE NUMBER 1	2	3	4	5	6	7	8	9	10	11
1	479.82	479.75	479.40	478.76	477.77	476.37	474.48	471.94	468.52	463.7[illegible]	456.[illegible]
2	495.98	495.83	495.20	494.13	492.57	490.41	487.52	483.69	478.5[illegible]	471.46	459.1[illegible]
3	523.16	522.80	522.45	521.60	520.18	518.15	515.38	511.74	506.97	500.59	494.51
4	559.69	560.93	560.16	558.33	555.27	550.76	544.55	536.32	525.71	512.16	499.[illegible]
5	605.66	605.77	607.55	606.42	602.11	594.38	582.89	567.31	547.19	521.95	480.03
6	651.59	667.70	669.66	668.55	664.57	657.92	648.75	637.20	623.36	607.12	593.55
7	496.91	499.39	507.17	513.08	516.82	520.08	524.46	528.55	531.25	533.43	539.45
7	493.37	497.41	506.09	512.38	516.30	519.78	524.47	528.95	532.23	535.65	543.85
8	511.04	526.39	535.59	543.14	549.04	554.97	562.36	569.84	576.45	583.22	582.41
9	527.70	531.05	533.65	537.14	540.99	544.14	547.22	550.46	550.98	546.33	546.[illegible]6
10	554.42	551.54	550.77	550.74	550.82	549.88	548.39	546.46	541.05	529.43	509.10
11	559.56	559.51	558.27	557.10	555.38	551.97	547.30	541.49	531.41	514.22	492.28
12	555.71	556.01	555.86	555.72	554.98	552.50	549.72	543.75	534.49	518.11	496.50

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
2	0.24010	1.40064	16.629	3218.0	17.2239	19.994	1.5510	1.5740

** VZ ARRAY - (Ft/sec) **

					STREAMLINE NUMBER						
STATION	1	2	3	4	5	6	7	8	9	10	11
1	479.69	479.62	479.31	478.71	477.78	476.46	474.65	472.22	468.89	464.15	456.77
2	496.16	496.02	495.43	494.41	492.87	490.73	487.80	483.87	479.51	470.92	456.90
3	523.78	523.34	522.80	521.74	520.15	517.97	515.12	511.48	506.86	500.83	494.99
4	560.52	561.87	561.34	559.61	556.45	551.63	544.94	536.16	525.09	511.61	499.84
5	608.28	607.80	608.45	606.59	602.15	594.88	584.35	569.98	550.75	525.05	479.84
6	637.36	654.78	661.15	664.79	665.33	662.64	656.57	646.92	633.58	616.34	599.48
7	495.81	498.90	505.40	509.54	511.56	513.57	517.22	521.03	523.82	527.04	534.85
7	496.51	499.25	505.51	509.51	511.47	513.42	517.03	520.80	523.53	526.63	534.35
8	506.28	523.09	533.26	541.11	546.71	551.86	558.00	563.69	567.80	571.56	569.14
9	517.93	521.70	524.73	528.43	532.32	535.56	538.95	542.90	544.53	541.73	544.52
10	547.08	544.24	543.34	543.22	543.17	542.06	540.35	538.14	532.16	519.75	499.66
11	549.82	550.09	549.30	548.56	547.22	544.23	540.05	534.87	525.36	509.74	487.93
12	547.33	547.80	547.78	547.73	547.02	544.60	540.96	536.27	527.24	511.13	[illegible]

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
3	0.24013	1.40064	17.289	3271.0	17.2239	19.918	1.5765	1.5740

** VZ ARRAY - (Ft/sec) **

					STREAMLINE NUMBER						
STATION	1	2	3	4	5	6	7	8	9	10	11
1	479.55	479.49	479.18	478.60	477.71	476.44	474.69	472.32	469.07	464.41	457.07
2	496.24	496.11	495.53	494.52	492.99	490.84	487.91	483.93	478.46	470.63	456.38
3	523.98	523.50	522.87	521.74	520.06	517.79	514.86	511.18	506.62	500.82	495.05
4	561.48	562.85	562.27	560.33	556.84	551.61	544.47	535.29	523.98	510.70	499.92
5	604.83	604.28	605.07	603.94	600.68	594.88	585.96	573.09	554.94	529.32	493.12
6	634.66	652.95	660.68	665.16	666.08	663.43	657.17	647.05	632.93	614.39	594.61
7	498.37	500.29	505.42	508.90	510.70	512.74	516.66	520.95	524.44	528.51	536.97
7	498.43	500.25	505.34	508.80	510.60	512.66	516.59	520.90	524.45	528.61	537.21
8	508.36	524.91	534.92	542.54	547.78	552.39	557.87	562.79	565.99	568.65	565.61
9	518.64	522.66	525.92	529.60	533.24	536.17	539.28	543.09	544.96	543.08	547.05
10	546.92	544.19	543.43	543.55	543.79	543.05	541.71	539.83	534.11	521.90	502.36
11	549.70	550.19	549.70	549.16	547.96	545.12	541.11	536.09	526.85	510.68	490.67
12	547.79	548.40	548.51	548.53	547.82	545.42	541.81	537.15	528.26	512.47	492.50

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
4	0.24012	1.40064	17.220	3265.4	17.2239	19.922	1.5739	1.5740

** VZ ARRAY - (Ft/sec) **

STREAMLINE NUMBER

Printed by reid from intruder

STATION	1	2	3	4	5	6	7	8	9	10	11
1	479.41	479.35	479.06	478.50	477.64	476.41	474.72	472.42	469.24	464.67	457.39
2	496.23	496.10	495.54	494.55	493.05	490.93	498.01	484.03	478.51	470.51	456.09
3	524.57	524.04	523.32	522.05	520.20	517.74	514.62	510.79	506.17	500.48	494.90
4	560.99	562.41	561.93	560.10	556.73	551.63	544.63	535.59	524.44	511.44	501.25
5	603.99	603.34	604.08	603.16	600.26	594.88	586.37	573.84	555.85	529.94	483.36
6	632.17	650.96	659.63	664.73	666.07	663.80	657.90	648.07	634.07	615.25	593.96
7	499.99	501.26	505.57	508.58	510.16	512.11	516.02	520.37	524.02	528.47	537.24
7	500.09	501.26	505.52	508.52	510.09	512.04	515.95	520.30	523.95	528.41	537.21
8	508.92	525.44	535.44	542.95	548.01	552.40	557.61	562.19	564.9[illegible]	566.87	563.42
9	518.75	522.86	526.17	529.76	533.20	535.85	538.67	542.27	544.15	542.96	547.90
10	546.35	543.60	542.81	543.01	543.40	542.84	541.71	540.03	534.44	522.39	503.54
11	548.97	549.54	549.17	548.74	547.66	544.93	541.04	536.14	527.04	511.23	492.10
12	547.60	548.22	548.34	548.35	547.65	545.25	541.65	537.02	529.18	512.65	493.5[illegible]

I	Ift	Z(Ift,JM) (Cm)	AR	I	Z(I,J) (Cm)	AF
1	1	-32.0000	0.0000	1	-32.0000	0.0000
2	2	-21.0000	1.5696	2	-21.0000	1.5696
3	3	-13.0000	1.9835	3	-13.0000	1.9835
4	4	-7.0000	2.4531	4	-7.0000	2.4531
5	5	-3.0000	3.4246	5	-3.0000	3.4246
6	6	0.5542	3.5080	6	0.5542	3.5080
7	7	3.5454	3.6478	7	3.5454	3.6478
8	8	7.4732	2.5960	8	7.4732	2.5960
9	9	11.5166	2.3936	9	11.5166	2.3936
10	10	14.0000	3.8650	10	14.0000	3.8650
11	11	18.0000	2.3978	11	18.0000	2.3978
12	12	23.0000	1.9181	12	23.0000	1.9191

Fact1 = 2.3777 Fact2 = 4.5924

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
5	0.24012	1.40064	17.229	3266.1	17.2239	19.916	1.5742	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	STREAMLINE NUMBER 1	2	3	4	5	6	7	8	9	10	11
1	479.31	479.25	478.97	478.42	477.58	476.38	474.73	472.48	469.36	464.85	457.62
2	496.23	496.11	495.56	494.57	493.08	490.96	488.05	484.06	478.50	470.37	455.84
3	524.88	524.32	523.54	522.19	520.25	517.68	514.44	510.52	505.89	500.30	494.56
4	560.64	562.09	561.66	559.90	556.60	551.60	544.70	535.75	524.69	511.93	502.63
5	603.21	602.57	603.40	602.73	600.17	595.15	586.97	574.67	556.75	530.40	481.54
6	638.38	657.69	666.14	670.79	671.32	668.18	661.36	650.35	634.57	612.93	586.93
7	497.55	497.92	502.01	505.32	507.54	510.63	516.22	522.45	528.50	536.61	548.76
7	497.22	497.58	501.76	505.14	507.39	510.52	516.20	522.53	528.81	537.42	550.30
8	513.26	527.38	537.01	544.40	549.34	554.04	560.03	565.53	569.47	573.69	574.71
9	523.33	527.86	531.38	535.02	538.42	540.92	543.52	546.95	548.85	548.16	552.88
10	551.40	548.62	547.78	547.96	548.39	547.86	546.73	545.04	539.45	527.37	509.03
11	553.39	554.26	554.01	553.66	552.66	549.97	546.08	541.20	532.17	516.60	497.61

12	.	552.38	553.22	553.37	553.37	552.66	559.21	546.53	541.92	532.[illegible]	517.59	499.57

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
6	0.24910	1.40064	16.932	3242.2	17.2239	20.259	1.5627	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	.	1	2	3	4	STREAMLINE NUMBER 5	6	7	8	9	10	11
1	.	479.23	479.17	478.89	478.36	477.53	476.36	474.74	472.53	469.46	465.00	457.91
2	.	496.25	496.13	495.58	494.60	493.11	490.99	488.08	484.07	478.47	470.24	455.62
3	.	525.04	524.46	523.63	522.23	520.22	517.57	514.26	510.29	505.65	500.17	494.46
4	.	560.27	561.75	561.40	559.71	556.50	551.62	544.83	535.97	524.98	512.36	503.35
5	.	603.19	602.48	603.24	602.64	600.19	595.28	587.16	574.89	556.90	530.25	491.28
6	.	635.66	655.36	664.59	669.82	670.88	668.33	662.16	651.77	636.42	614.91	587.92
7	.	496.15	496.35	500.36	503.59	505.62	508.52	513.95	519.99	525.92	534.32	547.04
7	.	496.23	496.38	500.36	503.58	505.60	508.49	513.90	519.91	525.82	534.18	546.89
8	.	510.15	524.79	534.83	542.36	547.26	551.90	557.85	563.26	567.00	570.89	571.79
9	.	520.24	524.77	528.24	531.76	534.96	537.16	539.39	542.40	543.81	542.59	[illegible]
10	.	547.49	544.71	543.82	544.02	544.50	544.01	542.91	541.19	535.42	522.94	504.[illegible]
11	.	549.50	550.40	550.19	549.87	548.88	546.17	542.23	537.22	527.94	511.97	492.66
12	.	548.78	549.62	549.72	549.68	548.92	546.38	542.58	537.69	528.53	512.71	493.34

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
7	0.24012	1.40064	17.252	3268.0	17.2239	20.226	1.5751	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	.	1	2	3	4	STREAMLINE NUMBER 5	6	7	8	9	10	11
1	.	479.17	479.11	478.83	478.31	477.50	476.34	474.74	472.56	469.53	465.12	457.96
2	.	496.28	496.17	495.61	494.63	493.13	491.01	488.09	484.07	478.44	470.12	455.41
3	.	525.14	524.55	523.70	522.28	520.24	517.55	514.21	510.21	505.60	500.20	494.52
4	.	560.20	561.70	561.37	559.69	556.51	551.64	544.87	536.02	525.03	512.49	503.72
5	.	602.51	601.77	602.59	602.20	600.04	595.44	587.60	575.54	557.63	530.75	481.62
6	.	634.66	654.68	664.34	669.69	670.73	668.20	662.13	651.92	636.69	615.06	587.50
7	.	497.18	496.94	500.55	503.64	505.63	508.51	513.90	519.88	525.81	534.30	547.14
7	.	497.22	496.93	500.52	503.60	505.60	508.48	513.87	519.85	525.79	534.28	547.13
8	.	511.07	525.60	535.51	542.87	547.58	552.00	557.72	562.94	566.48	570.11	570.93
9	.	520.53	525.14	528.71	532.27	535.45	537.60	539.74	542.64	543.99	542.65	545.76
10	.	547.76	544.98	544.10	544.33	544.86	544.42	543.37	541.71	535.99	523.31	503.77
11	.	549.62	550.59	550.48	550.25	549.33	546.69	542.80	537.82	528.57	512.42	492.26
12	.	549.18	550.06	550.20	550.18	549.42	546.89	543.08	538.18	528.99	512.95	492.70

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
8	0.24012	1.40064	17.219	3265.3	17.2239	20.231	1.5738	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	1	2	3	4	STREAMLINE NUMBER 5	6	7	8	9	10	11
1	479.12	479.06	478.78	478.26	477.46	476.32	474.75	472.60	469.60	465.23	458.10
2	496.31	496.19	495.64	494.65	493.15	491.03	488.10	484.08	478.42	470.02	455.25
3	525.23	524.62	523.75	522.31	520.24	517.53	514.15	510.13	505.53	500.20	494.54
4	560.07	561.59	561.29	559.64	556.50	551.68	544.95	536.13	525.15	512.67	504.09
5	602.01	601.24	602.11	601.89	599.94	595.56	587.92	576.00	558.15	531.07	481.93
6	634.02	654.28	664.23	669.62	670.62	668.07	662.07	651.99	636.91	615.32	587.32
7	497.72	497.17	500.49	503.49	505.47	508.36	513.73	519.68	525.60	534.18	547.09
7	497.75	497.16	500.48	503.47	505.45	508.34	513.71	519.66	525.58	534.16	547.08
8	511.47	525.96	535.82	543.06	547.61	551.87	557.44	562.52	565.90	569.34	570.08
9	520.53	525.18	528.80	532.36	535.52	537.62	539.69	542.51	543.82	542.53	545.57
10	547.70	544.90	544.00	544.24	544.80	544.41	543.41	541.81	536.16	523.49	503.79
11	549.39	550.40	550.34	550.16	549.30	546.71	542.88	537.96	528.76	512.65	492.37
12	549.11	549.99	550.13	550.11	549.36	546.83	543.03	538.13	528.96	512.92	492.52

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
9	0.24012	1.40064	17.226	3265.8	17.2239	20.229	1.5741	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	1	2	3	4	STREAMLINE NUMBER 5	6	7	8	9	10	11
1	479.07	479.01	478.74	478.23	477.43	476.30	474.75	472.63	469.67	465.33	458.23
2	496.33	496.22	495.67	494.68	493.17	491.05	488.12	484.08	478.40	469.95	455.11
3	525.29	524.68	523.80	522.33	520.25	517.50	514.10	510.07	505.47	500.21	494.59
4	559.91	561.45	561.18	559.57	556.47	551.71	545.04	536.26	525.28	512.85	504.32
5	601.63	600.84	601.74	601.64	599.86	595.64	588.14	576.34	558.52	531.30	482.28
6	633.42	653.80	663.96	669.34	670.25	667.66	661.69	651.74	636.94	615.83	588.55
7	498.25	497.45	500.54	503.47	505.43	508.32	513.69	519.67	525.75	534.49	547.13
7	498.26	497.44	500.52	503.44	505.41	508.30	513.67	519.65	525.75	534.50	547.11
8	511.95	526.42	536.23	543.36	547.78	551.89	557.34	562.35	565.78	569.19	569.70
9	520.65	525.33	528.97	532.54	535.68	537.73	539.74	542.47	543.73	542.49	545.58
10	547.76	544.94	544.01	544.27	544.85	544.49	543.54	541.97	536.36	523.70	504.05
11	549.29	550.33	550.32	550.18	549.37	546.83	543.05	538.16	528.99	512.94	492.72
12	549.19	550.07	550.21	550.19	549.44	546.92	543.12	538.22	529.05	513.02	492.66

ITER	CP	GAMMA	DHI	PSUM	DHCI	DHC	CPR	PR
10	0.24012	1.40064	17.218	3265.2	17.2239	20.237	1.5738	1.5740

** VZ ARRAY - (Ft/sec) **

STATION	1	2	3	4	STREAMLINE NUMBER 5	6	7	8	9	10	11
1	479.03	478.97	478.70	478.19	477.41	476.29	474.75	472.65	469.72	465.42	458.34

2	.	496.35	496.24	495.69	494.69	493.19	491.06	488.13	484.09	478.39	469.89	455.09
3	.	525.34	524.73	523.83	522.35	520.25	517.49	514.06	510.02	505.44	500.23	494.63
4	.	559.75	561.30	561.06	559.49	556.44	551.73	545.11	536.36	525.40	513.00	504.58
5	.	601.32	600.52	601.45	601.45	599.80	595.71	588.33	576.63	559.64	531.50	482.38
6	.	633.08	653.62	663.95	669.31	670.15	667.52	661.58	651.74	637.07	616.04	588.49
7	.	498.57	497.60	500.50	503.37	505.32	508.21	513.55	519.49	525.55	534.33	546.97
7	.	498.59	497.60	500.49	503.36	505.31	508.20	513.54	519.49	525.54	534.31	546.95
8	.	512.09	526.55	536.33	543.38	547.71	551.73	557.09	562.03	565.39	568.66	569.14
9	.	520.64	525.33	529.01	532.58	535.69	537.70	539.64	542.30	543.59	542.29	545.40
10	.	547.68	544.85	543.90	544.17	544.77	544.42	543.49	541.94	536.35	523.70	504.05
11	.	549.08	550.14	550.16	550.06	549.28	546.78	543.03	538.17	529.03	513.09	492.91
12	.	549.14	550.02	550.16	550.13	549.38	546.86	543.06	538.15	529.97	512.94	492.60

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*** COMPUTED COMPRESSOR DESIGN PARAMETERS FOR A ROTATIONAL SPEED OF. 16100.0. RPM ***

** THE CORRECTED WEIGHTFLOW PER UNIT OF CASING ANNULAR AREA AT THE INLET FACE OF THE FIRST BLADE ROW IS 199.78 KG SEC M*2 **

** MASS AVERAGED ROTOR AND STAGE AERODYNAMIC PARAMETERS **

STAGE NO.	BLADE TYPE	FLOW COEF.	HEAD COEF.	ID. HEAD COEF.	TOTAL PRESS RATIO	TOTAL TEMP. RATIO	ADIA. EFF.	POLY. EFF.	ASPECT RATIO	FOR. AX. SHAFT THRUST (Kg)	GAS BENDING MOMENTS FOR EACH BLADE FOR. AX (M-Kg)	TANG. (M-Kg)	TORQUE (M-Kg)	POWER (KW)
1	ROTOR	0.4654	0.2298	0.2579	1.6056	1.1626	0.8910	0.8980	2.54	448.11	0.862	-0.586	93.93	1387.[illegible]
1	STATOR	0.3906	0.2195	0.2579	1.5740	1.1626	0.8512	0.8604	2.43	-133.37	0.152	0.427		

** CUMULATIVE SUMS OF MASS AVERAGED ROTOR AND STAGE AERODYDAMIC PARAMETERS **

STAGE NO.	BLADE TYPE	WEIGHT FLOW (KG/SEC)	TOTAL PRESS. (KG/M*2)	TOTAL TEMP. (Deg K.)	TOTAL PRESS. RATIO	TOTAL TEMP. RATIO	HEAD COEF.	IDEAL HEAD COEF.	ADIA. EFF.	POLY EFF.	FOR. AX. SHAFT THRUST (Kg)	TORQUE (M-Kg)	POWER (Kw)	FRACT ENERGY
1	INLET	29.48	10130.0	288.17										
1	ROTOR	29.48	16264.7	335.02	1.6056	1.1626	0.2298	0.2579	0.8910	0.8980	136.58	93.93	1387.[illegible]	[illegible]
1	STATOR	29.48	15945.0	335.02	1.5740	1.1626	0.2195	0.2579	0.8512	0.8604	95.93			

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** VALUES OF PARAMETERS ON STREAMLINES AT STATION. 1. WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. 1 (Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.400	-32.000												
1	25.400	-32.000	146.01	146.01	0.00	146.01	0.4371	0.00	0.03	0.000	10130.0	288.17	8885.6	277.56
2	23.901	-32.000	145.99	145.99	0.00	145.99	0.4370	0.00	0.14	0.000	10130.0	288.17	8883.5	277.55
3	22.377	-32.000	145.91	145.91	0.00	145.91	0.4368	0.00	0.26	0.001	10130.0	288.17	8884.8	277.56
4	20.820	-32.000	145.75	145.76	0.00	145.76	0.4363	0.00	0.40	0.001	10130.0	288.17	8887.3	277.58
5	19.223	-32.000	145.51	145.52	0.00	145.52	0.4356	0.00	0.55	0.001	10130.0	288.17	8891.2	277.61
6	17.575	-32.000	145.17	145.18	0.00	145.18	0.4345	0.00	0.70	0.002	10130.0	288.17	8896.6	277.66
7	15.855	-32.000	144.71	144.72	0.00	144.72	0.4331	0.00	0.86	0.002	10130.0	288.17	8904.1	277.73
8	14.042	-32.000	144.07	144.09	0.00	144.09	0.4311	0.00	1.01	0.003	10130.0	288.17	8914.3	277.82

9	12.089	-32.000	143.17	143.20	0.00	143.20	0.4284	0.00	1.16	0.004	10130.0	288.17	8929.6	277.95
10	9.910	-32.000	141.86	141.90	0.00	141.90	0.4243	0.00	1.29	0.005	10130.0	288.17	8949.1	278.12
11	7.296	-32.000	139.70	139.75	0.00	139.75	0.4177	0.00	1.46	0.007	10130.0	288.17	8993.4	278.43
HUB	7.296	-32.000												

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 2, WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.400	-21.000												
1	25.400	-21.000	151.29	151.29	0.00	151.29	0.4535	0.00	-0.04	0.000	10130.0	288.17	8796.0	276.76
2	23.945	-21.000	151.25	151.26	0.00	151.26	0.4534	0.00	0.32	0.000	10130.0	288.17	8796.5	276.76
3	22.467	-21.000	151.09	151.10	0.00	151.10	0.4529	0.00	0.70	0.001	10130.0	288.17	8799.2	276.79
4	20.961	-21.000	150.78	150.81	0.00	150.81	0.4520	0.00	1.10	0.001	10130.0	288.17	8804.0	276.83
5	19.418	-21.000	150.32	150.38	0.00	150.38	0.4507	0.00	1.55	0.002	10130.0	288.17	8811.2	276.90
6	17.831	-21.000	149.68	149.77	0.00	149.77	0.4488	0.00	2.05	0.003	10130.0	288.17	8821.3	276.99
7	16.180	-21.000	148.78	148.94	0.00	148.94	0.4462	0.00	2.64	0.004	10130.0	288.17	8835.1	277.11
8	14.447	-21.000	147.55	147.81	0.00	147.81	0.4427	0.00	3.37	0.005	10130.0	288.17	8853.8	277.28
9	12.590	-21.000	145.81	146.23	0.00	146.23	0.4378	0.00	4.32	0.006	10130.0	288.17	8879.6	277.51
10	10.540	-21.000	143.22	143.93	0.00	143.93	0.4306	0.00	5.69	0.008	10130.0	288.17	8916.9	277.84
11	8.134	-21.000	138.68	140.03	0.00	140.03	0.4185	0.00	7.95	0.013	10130.0	288.17	8979.0	278.40
HUB	8.134	-21.000												

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** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 3, WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.400	-13.000												
1	25.400	-13.000	160.12	160.13	0.00	160.13	0.4812	0.00	0.11	0.001	10130.0	288.17	8644.8	275.39
2	24.009	-13.000	159.94	159.95	0.00	159.95	0.4806	0.00	0.63	0.001	10130.0	288.17	8647.9	275.42
3	22.600	-13.000	159.66	159.70	0.00	159.70	0.4799	0.00	1.24	0.001	10130.0	288.17	8652.3	275.46
4	21.168	-13.000	159.21	159.30	0.00	159.30	0.4786	0.00	1.90	0.002	10130.0	288.17	8659.2	275.52
5	19.708	-13.000	158.57	158.74	0.00	158.74	0.4768	0.00	2.62	0.002	10130.0	288.17	8669.0	275.61
6	18.212	-13.000	157.73	158.01	0.00	158.01	0.4746	0.00	3.42	0.003	10130.0	288.17	8681.6	275.73
7	16.666	-13.000	156.69	157.13	0.00	157.13	0.4718	0.00	4.30	0.003	10130.0	288.17	8696.9	275.86
8	15.060	-13.000	155.45	156.12	0.00	156.12	0.4686	0.00	5.31	0.003	10130.0	288.17	8714.2	276.02
9	13.366	-13.000	154.06	155.06	0.00	155.06	0.4653	0.00	6.52	0.003	10130.0	288.17	8732.1	276.18
10	11.547	-13.000	152.47	154.01	0.00	154.01	0.4620	0.00	8.12	0.002	10130.0	288.17	8749.9	276.34
11	9.532	-13.000	150.76	153.44	0.00	153.44	0.4602	0.00	10.72	-0.001	10130.0	288.17	8759.7	276.43
HUB	9.532	-13.000												

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 4, WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1. Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg K.)	STATIC PRESS. Kg m^2	STATIC TEMP. (Deg.K.)
TIP	25.400	-7.000												
1	25.400	-7.000	170.61	170.62	0.00	170.62	0.5143	0.00	-0.35	-0.003	10130.0	288.17	8456.6	273.66
2	24.078	-7.000	171.08	171.09	0.00	171.09	0.5159	0.00	0.58	-0.001	10130.0	288.17	8447.8	273.59
3	22.746	-7.000	171.01	171.07	0.00	171.07	0.5158	0.00	1.50	0.000	10130.0	288.17	8448.2	273.59
4	21.398	-7.000	170.53	170.69	0.00	170.69	0.5146	0.00	2.48	0.002	10130.0	288.17	8455.2	273.65
5	20.028	-7.000	169.60	169.93	0.00	169.93	0.5121	0.00	3.53	0.003	10130.0	288.17	8469.2	273.78
6	18.632	-7.000	168.17	168.73	0.00	168.73	0.5084	0.00	4.68	0.005	10130.0	288.17	8491.1	273.98
7	17.195	-7.000	166.15	167.04	0.00	167.04	0.5030	0.00	5.93	0.007	10130.0	288.17	8521.7	274.26
8	15.708	-7.000	163.48	164.81	0.00	164.81	0.4960	0.00	7.28	0.009	10130.0	288.17	8561.8	274.63
9	14.149	-7.000	160.14	162.02	0.00	162.02	0.4872	0.00	8.73	0.010	10130.0	288.17	8611.9	275.09
10	12.487	-7.000	156.36	158.87	0.00	158.87	0.4773	0.00	10.20	0.012	10130.0	288.17	8666.7	275.59
11	10.681	-7.000	153.79	156.85	0.00	156.85	0.4709	0.00	11.32	0.005	10130.0	288.17	8701.9	275.91
HUB	10.631	-7.000												

1

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 5, WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM CURV. (1. Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg K.)	STATIC PRESS. Kg m^2	STATIC TEMP. (Deg.K.)
TIP	25.398	-3.000												
1	25.368	-3.000	183.28	183.29	0.00	183.29	0.5548	0.00	-0.31	0.004	10130.0	288.17	8217.6	271.42
2	24.109	-3.000	183.04	183.04	0.00	183.04	0.5540	0.00	0.36	0.002	10130.0	288.17	8222.3	271.47
3	22.843	-3.000	183.32	183.37	0.00	183.37	0.5551	0.00	1.31	-0.002	10130.0	288.17	8216.0	271.41
4	21.570	-3.000	183.32	183.49	0.00	183.49	0.5555	0.00	2.45	-0.001	10130.0	288.17	8213.7	271.39
5	20.284	-3.000	182.82	183.22	0.00	183.22	0.5546	0.00	3.79	0.001	10130.0	288.17	8218.9	271.44
6	18.982	-3.000	181.57	182.36	0.00	182.36	0.5518	0.00	5.34	0.003	10130.0	288.17	8235.4	271.59
7	17.652	-3.000	179.32	180.72	0.00	180.72	0.5466	0.00	7.12	0.005	10130.0	288.17	8267.0	271.89
8	16.285	-3.000	175.76	178.03	0.00	178.03	0.5380	0.00	9.18	0.009	10130.0	288.17	8318.1	272.37
9	14.861	-3.000	170.34	173.88	0.00	173.88	0.5247	0.00	11.59	0.014	10130.0	288.17	8396.2	273.10
10	13.347	-3.000	162.00	167.36	0.00	167.36	0.5040	0.00	14.54	0.023	10130.0	288.17	8516.0	274.21
11	11.669	-3.000	147.03	154.84	0.00	154.84	0.4646	0.00	18.27	0.051	10130.0	288.17	8735.[illegible]	276.22
HUB	11.600	-3.000												

1

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 6, WHICH IS THE INLET OF ROTOR NUMBER, 1 **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1. Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg m^2	STATIC TEMP. (Deg.K.)
TIP	25.338	0.949												
1	25.272	0.943	192.96	193.43	0.00	193.43	0.5876	0.00	-3.99	-0.036	10130.0	288.17	8017.8	269.52
2	24.072	0.840	199.22	199.35	0.00	199.35	0.6069	0.00	-2.08	-0.017	10130.0	288.17	7897.9	268.36
3	22.883	0.774	202.37	202.38	0.00	202.38	0.6167	0.00	-0.39	-0.012	10130.0	288.17	7835.8	267.75
4	21.697	0.704	204.01	204.06	0.00	204.06	0.6223	0.00	1.38	-0.008	10130.0	288.17	7800.9	267.41
5	20.507	0.626	204.26	204.58	0.00	204.58	0.6240	0.00	3.21	-0.005	10130.0	288.17	7790.1	267.31
6	19.308	0.548	203.46	204.28	0.00	204.28	0.6230	0.00	5.13	-0.004	10130.0	288.17	7796.4	267.37
7	18.092	0.463	201.65	203.28	0.00	203.28	0.6197	0.00	7.26	-0.003	10130.0	288.17	7817.1	267.57
8	16.852	0.371	198.65	201.54	0.00	201.54	0.6140	0.00	9.71	-0.002	10130.0	288.17	7853.0	267.92
9	15.573	0.262	194.18	198.99	0.00	198.99	0.6057	0.00	12.63	-0.003	10130.0	288.17	7905.3	268.43
10	14.235	0.129	187.77	195.55	0.00	195.55	0.5945	0.00	16.22	-0.006	10130.0	288.17	7975.1	269.11

Printed by reid from intruder

11	12.812	0.009	179.37	192.39	0.00	192.39	0.5842	0.00	21.29	0.018	19139.6	288.17	8038.7
HUB	12.667	-0.003											

STREAMLINE NO.	R/RTIP	REL.FLOW ANGLE (Deg)	REL. TANG.VEL. (M/sec)	REL. VEL. (M/sec)	REL.MACH NUMBER	WHEEL SPEED (M/sec)	FLOW COEF.	L.E.RAD. /CHORD	MAX.TH. CHORD	MAX.TH PT.LOC. CHORD	TRAN.PT. LOCATION CHORD	SEGMENT IN/OUT TURN.RATE	LAYOUT CONE ANG. (Deg)
TIP	1.0000					427.20							
1	0.9974	65.58	426.08	467.93	1.4214	426.08	0.4517	0.0055	0.0330	0.5000	0.7000	0.0000	-4.63
2	0.9500	63.84	405.86	452.18	1.3765	405.86	0.4663	0.0055	0.0377	0.5000	0.6800	0.2500	-2.44
3	0.9031	62.32	385.81	435.67	1.3277	385.81	0.4737	0.0055	0.0423	0.5000	0.6600	0.5000	-0.59
4	0.8563	60.85	365.81	418.88	1.2774	365.81	0.4775	0.0055	0.0470	0.5000	0.6400	0.7500	1.26
5	0.8093	59.39	345.74	401.74	1.2253	345.74	0.4781	0.0055	0.0516	0.5000	0.6200	1.0000	3.07
6	0.7620	57.89	325.53	384.32	1.1721	325.53	0.4763	0.0055	0.0563	0.5000	0.6000	1.0000	4.88
7	0.7140	56.32	305.03	366.56	1.1175	305.03	0.4720	0.0055	0.0611	0.5000	0.5400	1.0000	6.94
8	0.6651	54.65	284.13	348.35	1.0613	284.13	0.4650	0.0055	0.0659	0.5000	0.4800	1.0000	9.04
9	0.6146	52.84	262.56	329.45	1.0027	262.56	0.4545	0.0055	0.0709	0.5000	0.4200	1.0000	11.57
10	0.5618	50.83	240.00	309.58	0.9411	240.00	0.4395	0.0055	0.0762	0.5000	0.3600	1.0000	14.49
11	0.5056	48.31	216.00	289.26	0.8783	216.00	0.4199	0.0055	0.0817	0.5000	0.3000	1.0000	18.17
HUB	0.4999												

--- INLET STREAMLINE --- ++++++++++++++++++++++++++++++ LAYOUT CONE ++++++++++++++++++++++++++++++++++++

STREAMLINE NO.	PCT. PASS.	INC. ANGLE (Deg)	S.S.INC. ANGLE (Deg)	IN.BLADE ANGLE (Deg)	IN.BLADE ANGLE (Deg)	TRAN.PT. BL.ANGLE (Deg)	BLD.SET ANGLE (Deg)	1st SEG. S.S.CAM. (Deg)	MACH NO. AT SHOCK LOCATION	SH.LOC. AS FRACT OF S.S.	COV.CHAN. AS FRACT OF S.S	MIN.CHK. AREA MARGIN	MIN.CHK. PT.LOC.IN COV.CHAN	L.E.EDGE CIR.CENT R*D0 DR
1	0.53	2.55	0.00	63.03	63.03	63.03	62.20	3.58	1.4807	0.6809	0.3191	0.0543	1.0000	-0.1621
2	9.99	3.09	0.00	60.75	60.75	59.48	59.54	5.48	1.4632	0.6298	0.3702	0.0665	1.0000	-0.0772
3	19.37	3.63	0.00	58.69	58.69	57.70	57.86	5.79	1.4166	0.5859	0.4141	0.0446	1.0000	-0.0469
4	28.74	4.16	0.00	56.69	56.69	55.54	55.76	6.48	1.3738	0.5417	0.4583	0.0398	1.0000	-0.0459
5	38.13	4.69	0.00	54.70	54.71	52.75	53.13	7.78	1.3372	0.4967	0.5033	0.0500	1.0000	-0.0479
6	47.59	5.21	0.00	52.68	52.69	49.81	50.30	9.14	1.2994	0.4523	0.5477	0.0534	0.0000	-0.0479
7	57.19	5.74	0.00	50.58	50.62	46.77	47.07	10.05	1.2630	0.4077	0.5923	0.0493	0.0000	-0.0539
8	66.97	6.25	0.00	48.40	48.48	43.49	43.30	10.98	1.2289	0.3629	0.6371	0.0471	0.0000	0.0677
9	77.07	6.71	0.00	46.13	46.30	39.77	38.57	12.10	1.2018	0.3174	0.6826	0.0474	0.0000	-0.0944
10	87.63	7.07	0.00	43.76	44.09	35.50	32.27	13.51	1.1434	0.2705	0.7295	0.0528	0.0000	-0.1012
11	98.85	7.24	0.00	41.07	41.76	31.99	25.75	13.68	1.0636	0.2252	0.7748	0.0525	0.0000	-0.0825

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PAGE NO 13

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 7, WHICH IS THE OUTLET OF ROTOR NUMBER, 1 **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg m^2	STATIC TEMP. (Deg.K.)
TIP	25.181	3.142												
1	25.093	3.149	151.97	152.27	124.64	196.78	0.5476	39.30	-3.61	0.042	16264.7	340.65	13265.3	321.40
2	23.970	3.240	151.67	151.74	124.10	196.02	0.5476	39.28	-1.78	0.020	16264.7	338.08	13265.8	318.98
3	22.858	3.291	152.55	152.55	125.38	197.46	0.5534	39.42	-0.24	0.013	16264.7	336.26	13209.5	316.87
4	21.755	3.363	153.42	153.47	127.86	199.75	0.5615	39.80	1.34	0.007	16264.7	334.85	13131.5	315.01
5	20.659	3.456	154.02	154.22	133.28	203.83	0.5741	40.83	2.93	0.001	16264.7	334.37	13007.9	313.71
6	19.565	3.552	154.90	155.38	139.33	208.70	0.5892	41.88	4.53	-0.003	16264.7	333.92	12859.1	312.25
7	18.475	3.658	156.53	157.46	146.17	214.84	0.6082	42.87	6.23	-0.008	16264.7	333.49	12669.3	310.53
8	17.393	3.772	158.34	159.91	153.96	221.98	0.6304	43.91	8.06	-0.013	16264.7	333.11	12445.1	308.60
9	16.318	3.901	160.18	162.66	164.46	231.31	0.6590	45.32	10.01	-0.019	16264.7	333.21	12151.6	306.59
10	15.248	4.050	162.86	166.54	175.68	242.08	0.6926	46.53	12.07	-0.026	16264.7	333.12	11802.4	303.97
11	14.178	4.174	166.71	172.00	189.10	255.62	0.7354	47.71	14.25	-0.039	16264.7	333.16	11353.1	300.65
HUB	14.018	4.192												

STREAMLINE REL.FLOW REL. REL. REL.MACH WHEEL FLOW HEAD IDEAL HEAD ADIAB. DIFFUSION LOSS SHOCK DEGREE

NO.	R/RTIP	ANGLE (Deg)	TANG.VEL. (M/sec)	VEL. (M/sec)	NUMBER	SPEED (M/sec)	COEF.	COEF.	COEF	EFF	FACTOR	COEF.	LOSS COEF	REACTION
TIP	1.0000													
1	0.9965	62.97	298.43	335.03	0.9324	423.07	0.3557	0.2298	0.2889	0.7953	0.3859	0.1508	0.0421	0.8554
2	0.9519	61.55	280.04	318.51	0.8897	404.13	0.3550	0.2298	0.2748	0.8362	0.3958	0.1208	0.0408	0.8750
3	0.9077	59.60	260.00	301.45	0.8449	385.38	0.3571	0.2298	0.2647	0.8680	0.4083	0.0987	0.0351	0.8759
4	0.8639	57.29	238.93	283.97	0.7982	366.79	0.3591	0.2298	0.2570	0.8943	0.4232	0.0809	0.0300	0.8689
5	0.8204	54.35	215.02	264.61	0.7453	348.30	0.3605	0.2298	0.2544	0.9034	0.4457	0.0771	0.0257	0.8505
6	0.7770	50.80	190.53	245.86	0.6941	329.86	0.3626	0.2298	0.2518	0.9125	0.4682	0.0732	0.0212	0.9253
7	0.7337	46.40	165.32	228.30	0.6463	311.49	0.3664	0.2298	0.2495	0.9211	0.4891	0.0697	0.0171	0.7909
8	0.6907	41.06	139.29	212.07	0.6022	293.25	0.3706	0.2298	0.2474	0.9289	0.5077	0.0670	0.0134	0.7495
9	0.6480	34.23	110.66	196.73	0.5605	275.12	0.3750	0.2298	0.2479	0.9269	0.5256	0.0748	0.0108	0.6922
10	0.6055	26.04	81.39	185.37	0.5303	257.07	0.3812	0.2298	0.2475	0.9286	0.5305	0.0802	0.0051	0.6239
11	0.5631	16.19	49.94	179.11	0.5152	239.05	0.3902	0.2298	0.2477	0.9277	0.5170	0.0905	0.0097	0.5403
HUB	0.5567													

STREAMLINE NO.	PCT. SPAN	PRESS. RATIO	TEMP. RATIO	AERO. CHORD (Cm.)	ELEMENT SOLIDITY	LOCAL BLADE FORCES RADIUS (Cm.)	FOR.AXIAL (Kg/cm)	TANG. (Kg/cm)	--- OUTLET STREAMLINE --- T.E.RAD. /CHORD	DEV. ANGLE (Deg)	OUT.BLADE ANGLE (Deg)	++ LAYOUT CONE +++ OUT.BLADE ANGLE (Deg)	MAX.CAMB. PT.LOC. CHORD	T.E.EDGE CIR.CENT R*DO DR
1	0.79	1.6056	1.1821	4.6864	1.3032	25.183	1.5869	-0.9218	0.0055	5.40	57.57	57.49	0.7440	0.1343
2	10.85	1.6056	1.1732	4.6873	1.3665	24.021	1.4978	-0.9010	0.0055	4.40	57.15	57.13	0.6507	0.0556
3	20.82	1.6056	1.1669	4.6864	1.4350	22.871	1.4079	-0.8746	0.0055	2.90	56.70	56.69	0.5567	0.0386
4	30.69	1.6056	1.1620	4.6867	1.5106	21.726	1.3161	-0.8512	0.0055	2.60	54.69	54.69	0.5209	0.0731
5	40.52	1.6056	1.1603	4.6884	1.5951	20.583	1.2138	-0.8409	0.0055	2.80	51.55	51.55	0.4994	0.0995
6	50.31	1.6056	1.1587	4.6921	1.6905	19.437	1.1112	-0.8282	0.0055	2.90	47.90	47.90	0.4989	0.0953
7	60.08	1.6056	1.1573	4.6994	1.7999	18.284	1.0069	-0.8143	0.0055	2.90	43.50	43.50	0.4983	0.1100
8	69.77	1.6056	1.1560	4.7126	1.9273	17.123	0.8999	-0.7971	0.0055	3.00	38.06	38.07	0.4974	0.1492
9	79.40	1.6056	1.1563	4.7367	2.0802	15.946	0.7828	-0.7822	0.0055	3.60	30.63	30.73	0.4961	0.1994
10	88.99	1.6056	1.1560	4.7790	2.2703	14.741	0.6615	-0.7565	0.0055	6.20	19.84	20.17	0.4942	0.2346
11	98.57	1.6056	1.1561	4.8583	2.5211	13.495	0.5272	-0.7703	0.0055	7.80	8.39	9.19	0.4913	0.2441

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** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 8, WHICH IS THE INLET OF STATOR NUMBER, 1, OF STAGE NUMBER, 1 **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg m^2	STATIC TEMP. (Deg.K.)
TIP	25.146	7.429												
1	25.064	7.429	156.09	156.10	124.79	199.85	0.5567	38.64	0.82	0.006	16264.7	340.65	13179.0	320.79
2	23.983	7.439	160.49	160.53	124.03	202.86	0.5679	37.69	1.19	0.000	16264.7	338.08	13069.3	317.62
3	22.930	7.449	163.47	163.55	124.98	205.84	0.5784	37.39	1.71	0.000	16264.7	336.26	12965.9	315.19
4	21.895	7.456	165.62	165.76	127.04	208.84	0.5887	37.47	2.30	-0.002	16264.7	334.85	12863.7	313.16
5	20.872	7.469	166.94	167.17	131.92	212.95	0.6016	38.28	3.02	0.003	16264.7	334.37	12735.4	311.82
6	19.857	7.481	168.17	168.55	137.29	217.39	0.6155	39.16	3.88	-0.005	16264.7	333.92	12595.6	310.41
7	18.848	7.494	169.80	170.41	143.28	222.64	0.6320	40.06	4.84	-0.007	16264.7	333.49	12428.5	308.83
8	17.848	7.509	171.31	172.22	150.05	228.41	0.6501	41.06	5.89	-0.009	16264.7	333.11	12242.9	307.16
9	16.853	7.528	172.33	173.65	159.24	235.61	0.6723	42.52	7.07	-0.010	16264.7	333.21	12013.7	305.59
10	15.860	7.547	173.33	175.20	168.90	243.36	0.6966	43.95	8.39	-0.011	16264.7	333.12	11760.5	303.66
11	14.867	7.569	173.48	176.06	180.34	252.03	0.7239	45.69	9.83	-0.005	16264.7	333.16	11473.6	301.56
HUB	14.726	7.572												

STREAMLINE NO.	R/RTIP	FLOW COEF.	REL.FLOW ANGLE (Deg)	L.E.RAD. /CHORD	MAX.TH. /CHORD	MAX.TH. PT.LOC. /CHORD	TRAN.PT. LOCATION /CHORD	SEGMENT IN/OUT TURN.RATE	LAYOUT CONE ANG. (DEG)
TIP	1.0000								
1	0.9967	0.3654	62.34	0.0062	0.0669	0.5000	0.4000	0.5000	0.04
2	0.9537	0.3757	60.20	0.0070	0.0689	0.5000	0.4000	0.5000	0.78

Printed by reid from intruder

3	0.9119	0.3827	57.99	0.0078	0.0710	0.5000	0.4000	0.5000	1.38
4	0.8707	0.3877	55.60	0.0086	0.0729	0.5000	0.4000	0.5000	1.93
5	0.8300	0.3908	52.77	0.0094	0.0749	0.5000	0.4000	0.5000	2.52
6	0.7896	0.3936	49.52	0.0102	0.0769	0.5000	0.4000	0.5000	3.17
7	0.7495	0.3975	45.68	0.0109	0.0788	0.5000	0.4000	0.5000	3.88
8	0.7098	0.4010	41.22	0.0117	0.0807	0.5000	0.4000	0.5000	4.64
9	0.6702	0.4034	35.73	0.0125	0.0826	0.5000	0.4000	0.5000	5.51
10	0.6307	0.4057	29.35	0.0132	0.0845	0.5000	0.4000	0.5000	6.45
11	0.5912	0.4061	21.77	0.0140	0.0864	0.5000	0.4000	0.5000	7.51
HUB	0.5856								

	--- INLET STREAMLINE ---		+++++++++++++++++++++++++++++ LAYOUT CONE						+++++++++++++++++++++++++++++++++++++				
STREAMLINE NO.	PCT. PASS.	INC. ANGLE (Deg)	S.S.INC. ANGLE (Deg)	IN.BLADE ANGLE (Deg)	IN.BLADE ANGLE (Deg)	TRAN.PT. BL.ANGLE (Deg)	BLD.SET ANGLE (Deg)	1st SEG. S.S.CAM. (Deg)	MACH NO. AT SHOCK LOCATION	SH.LOC. AS FRACT OF S.S.	COV.CHAN. AS FRACT OF S.S.	MIN.CHK. AREA MARGIN	MIN.CHK. PT.LOC.IN COV.CHAN.	L.E.EDGE CIR.CENT R*DO DR
1	0.79	6.09	0.00	32.55	32.54	20.86	12.70	16.56	0.7137	0.3298	0.5417	0.3247	0.0000	0.0280
2	11.16	6.13	0.00	31.56	31.55	20.92	13.50	15.50	0.7140	0.3148	0.5853	0.2916	0.0000	0.0369
3	21.27	6.16	0.00	31.23	31.22	21.12	14.09	14.95	0.7188	0.3032	0.6140	0.2669	0.0000	0.0425
4	31.20	6.17	0.00	31.30	31.29	21.32	14.39	14.79	0.7268	0.2932	0.6309	0.2457	0.0000	0.0550
5	41.02	6.17	0.00	32.11	32.09	21.96	14.95	14.91	0.7418	0.2879	0.6400	0.2255	0.0000	0.0681
6	50.76	6.17	0.00	32.99	32.98	22.64	15.51	15.07	0.7581	0.2824	0.6485	0.2046	0.0000	0.0725
7	60.44	6.16	0.00	33.89	33.88	23.33	16.08	15.23	0.7773	0.2762	0.6576	0.1812	0.0000	0.0792
8	70.04	6.16	0.00	34.91	34.88	24.13	16.75	15.39	0.7985	0.2701	0.6673	0.1570	0.0000	0.0938
9	79.58	6.14	0.00	36.38	36.36	25.26	17.66	15.69	0.8263	0.2657	0.6746	0.1317	0.0000	0.1061
10	89.11	6.12	0.00	37.83	37.81	26.34	18.51	16.00	0.8560	0.2598	0.6828	0.1047	0.0000	0.1171
11	98.65	6.09	0.00	39.60	39.59	27.62	19.47	16.43	0.8903	0.2540	0.6898	0.0782	0.0000	0.1333

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PAGE NO 15

** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 9, WHICH IS THE OUTLET OF STATOR NUMBER, 1, OF STAGE NUMBER, 1 **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.146	11.509												
1	25.067	11.509	158.69	158.71	0.00	158.71	0.4372	0.00	-0.79	-0.008	15990.6	340.55	14019.5	328.91
2	24.038	11.507	160.12	160.12	0.00	160.12	0.4430	0.00	0.13	-0.007	16012.3	338.05	13994.2	325.30
3	23.027	11.507	161.24	161.26	0.00	161.26	0.4475	0.00	0.80	-0.008	16022.1	336.26	13964.9	323.33
4	22.032	11.510	162.33	162.38	0.00	162.38	0.4516	0.00	1.34	-0.008	16028.1	334.86	13934.6	321.75
5	21.050	11.513	163.28	163.36	0.00	163.36	0.4548	0.00	1.83	-0.009	16023.9	334.39	13903.7	321.12
6	20.080	11.516	163.89	164.02	0.00	164.02	0.4571	0.00	2.28	-0.011	15998.3	333.93	13862.5	320.55
7	19.120	11.518	164.48	164.66	0.00	164.66	0.4592	0.00	2.70	-0.014	15964.1	333.51	13814.3	320.02
8	18.173	11.520	165.29	165.53	0.00	165.53	0.4620	0.00	3.07	-0.018	15920.9	333.13	13753.2	319.50
9	17.238	11.521	165.66	165.95	0.00	165.95	0.4632	0.00	3.38	-0.024	15844.2	333.23	13677.1	319.53
10	16.310	11.521	165.29	165.61	0.00	165.61	0.4622	0.00	3.55	-0.033	15700.8	333.14	13561.2	319.50
11	15.388	11.521	166.24	166.52	0.00	166.52	0.4649	0.00	3.35	-0.053	15537.1	333.19	13397.8	319.39
HUB	15.258	11.521												

STREAMLINE NO.	R/RTIP	FLOW COEF.	HEAD COEF.	IDEAL HEAD COEF.	STATOR PO.RATIO	STAGE PO.RATIO	STAGE AD.EFF.	DIFFUSION FACTOR	STATOR LOSS COEF.	SHOCK LOSS COEF.	ELEMENT SOLIDITY	AERO. CHORD (Cm.)	DEGREE REACTION
TIP	1.0000												
1	0.9968	0.3715	0.2210	0.2889	0.9832	1.5785	0.7648	0.4509	0.0888	0.0000	1.2741	4.1804	0.1372
2	0.9559	0.3748	0.2217	0.2748	0.9845	1.5807	0.8068	0.4402	0.0790	0.0000	1.3302	4.1807	0.1508
3	0.9157	0.3774	0.2220	0.2647	0.9851	1.5816	0.8386	0.4345	0.0735	0.0000	1.3902	4.1815	0.1628
4	0.8762	0.3800	0.2222	0.2570	0.9855	1.5822	0.8647	0.4309	0.0696	0.0000	1.4548	4.1825	0.1746
5	0.8371	0.3822	0.2221	0.2544	0.9852	1.5818	0.8731	0.4351	0.0682	0.0000	1.5249	4.1840	0.1904
6	0.7985	0.3836	0.2212	0.2518	0.9836	1.5793	0.8786	0.4416	0.0726	0.0000	1.6015	4.1861	0.2065
7	0.7604	0.3850	0.2201	0.2495	0.9815	1.5759	0.8824	0.4499	0.0784	0.0000	1.6856	4.1888	0.2259

8	0.7227	0.3869	0.2187	0.2474	0.9789	1.5717	0.8842	0.4583	0.0855	0.0000	1.7783	4.1924	0.2462
9	0.6855	0.3878	0.2162	0.2479	0.9741	1.5641	0.8723	0.4733	0.0999	0.0000	1.8911	4.1972	0.2712
10	0.6486	0.3869	0.2116	0.2475	0.9653	1.5499	0.8550	0.4909	0.1252	0.0000	1.9963	4.2033	0.2935
11	0.6120	0.3891	0.2062	0.2477	0.9553	1.5338	0.8325	0.5046	0.1519	0.0000	2.1266	4.2111	0.3137
HUB	0.6068												

STREAMLINE NO.	PCT. SPAN	LOCAL BLADE FORCES RADIUS (Cm.)	FOR.AXIAL (Kg/cm)	TANG. (Kg/cm)	--- OUTLET STREAMLINE --- T.E.RAD. /CHORD	DEV. ANGLE (Deg)	OUT.BLADE ANGLE (Deg)	++ LAYOUT CONE +++ OUT.BLADE ANGLE (Deg)	MAX.CAMB. PT.LOC. /CHORD	T.E.EDGE CIR.CENT R*D0/DR
1	0.80	25.065	0.2955	0.9319	0.0061	14.20	-14.20	-14.26	0.5417	-0.0735
2	11.20	24.011	0.2869	0.9147	0.0061	11.10	-11.10	-11.13	0.5415	-0.0537
3	21.43	22.979	0.2826	0.8959	0.0061	9.40	-9.40	-9.42	0.5415	-0.0343
4	31.50	21.964	0.2823	0.8791	0.0061	8.90	-8.90	-8.91	0.5417	-0.0259
5	41.42	20.961	0.2922	0.8755	0.0061	8.80	8.80	-8.81	0.5419	-0.0273
6	51.23	19.969	0.2983	0.8698	0.0061	8.80	-8.80	-8.82	0.5421	-0.0283
7	60.94	18.984	0.3044	0.8644	0.0061	8.80	-8.80	-8.83	0.5423	-0.0317
8	70.51	18.011	0.3110	0.8586	0.0061	8.70	-8.70	-8.74	0.5425	-0.0378
9	79.97	17.046	0.3203	0.8581	0.0061	8.70	-8.70	-8.76	0.5427	-0.0411
10	89.36	16.085	0.3185	0.8510	0.0061	8.80	-8.80	-8.88	0.5428	-0.0423
11	98.68	15.128	0.3194	0.8767	0.0061	9.10	-9.10	-9.22	0.5430	-0.0442

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** VALUES OF PARAMETERS ON STREAMLINES AT STATION. 10. WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.146	14.000												
1	25.026	14.000	166.93	166.95	0.00	166.95	0.4609	0.00	-0.65	0.010	15990.6	340.55	13822.6	326.69
2	24.032	14.000	166.07	166.07	0.00	166.07	0.4601	0.00	-0.18	0.003	16012.3	338.05	13849.2	324.33
3	23.046	14.000	165.78	165.78	0.00	165.78	0.4605	0.00	0.22	0.000	16022.1	336.26	13853.8	322.59
4	22.071	14.000	165.86	165.87	0.00	165.87	0.4618	0.00	0.56	-0.003	16028.1	334.86	13848.1	321.18
5	21.106	14.000	166.05	166.06	0.00	166.06	0.4627	0.00	0.84	-0.004	16023.9	334.39	13836.7	320.68
6	20.151	14.000	165.94	165.97	0.00	165.97	0.4627	0.00	1.04	-0.006	15998.3	333.93	13814.1	320.22
7	19.202	14.000	165.66	165.69	0.00	165.69	0.4622	0.00	1.17	-0.007	15964.1	333.51	13788.8	319.85
8	18.262	14.000	165.18	165.22	0.00	165.22	0.4611	0.00	1.19	-0.008	15920.9	333.13	13760.9	319.55
9	17.327	14.000	163.48	163.51	0.00	163.51	0.4561	0.00	1.04	-0.007	15844.2	333.23	13737.2	319.93
10	16.386	14.000	159.62	159.63	0.00	159.63	0.4449	0.00	0.64	-0.006	15700.8	333.14	13705.5	320.47
11	15.428	14.000	153.63	153.63	0.00	153.63	0.4275	0.00	-0.15	0.004	15537.1	333.19	13701.9	321.44
HUB	15.232	14.000												

** VALUES OF PARAMETERS ON STREAMLINES AT STATION. 11. WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.146	18.000												

1	25.026	18.000	167.36	167.36	0.00	167.36	0.4621	0.00	0.22	-0.002	15990.6	340.55	13812.7	326.62
2	24.037	18.000	167.68	167.68	0.00	167.68	0.4648	0.00	0.14	-0.001	16012.3	339.05	13809.2	324.07
3	23.060	18.000	167.69	167.69	0.00	167.69	0.4661	0.00	0.13	-0.001	16022.1	336.26	13806.2	322.27
4	22.095	18.000	167.66	167.66	0.00	167.66	0.4670	0.00	0.14	-0.001	16028.1	334.86	13804.2	320.99
5	21.138	18.000	167.42	167.42	0.00	167.42	0.4666	0.00	0.16	-0.001	16023.9	334.39	13803.5	320.46
6	20.189	18.000	166.66	166.66	0.00	166.66	0.4647	0.00	0.18	-0.001	15998.3	333.93	13796.8	320.12
7	19.243	18.000	165.52	165.52	0.00	165.52	0.4617	0.00	0.18	-0.001	15964.1	333.51	13793.1	319.88
8	18.303	18.000	164.03	164.04	0.00	164.04	0.4577	0.00	0.17	-0.001	15920.9	333.13	13790.2	319.75
9	17.362	18.000	161.25	161.25	0.00	161.25	0.4495	0.00	0.14	-0.001	15844.2	333.23	13792.1	320.29
10	16.410	18.000	156.36	156.36	0.00	156.36	0.4354	0.00	0.12	-0.001	15700.8	333.14	13782.6	320.98
11	15.435	18.000	150.21	150.21	0.00	150.21	0.4177	0.00	0.16	-0.001	15537.1	333.19	13779.4	321.96
HUB	15.240	18.000												

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** VALUES OF PARAMETERS ON STREAMLINES AT STATION, 12, WHICH IS AN ANNULUS **

STREAMLINE NO.	RADIUS (Cm.)	AXIAL COORD. (Cm.)	AXIAL VEL. (M/sec)	MERD. VEL. (M/sec)	TANG. VEL. (M/sec)	ABS. VEL. (M/sec)	ABS. MACH NO.	ABS.FLOW ANGLE (Deg)	STREAM. SLOPE (Deg)	STREAM. CURV. (1./Cm.)	TOTAL PRESS. Kg/m^2	TOTAL TEMP. (Deg.K.)	STATIC PRESS. Kg/m^2	STATIC TEMP. (Deg.K.)
TIP	25.146	23.000												
1	25.026	23.000	167.38	167.38	0.00	167.38	0.4621	0.00	-0.18	-0.001	15990.6	340.51	13812.0	326.58
2	24.037	23.000	167.65	167.65	0.00	167.65	0.4647	0.00	-0.13	-0.001	16012.3	338.03	13809.9	324.06
3	23.060	23.000	167.69	167.69	0.00	167.69	0.4661	0.00	-0.14	-0.001	16022.1	336.26	13806.2	322.27
4	22.095	23.000	167.68	167.68	0.00	167.68	0.4670	0.00	-0.16	-0.001	16028.1	334.87	13803.6	320.89
5	21.138	23.000	167.45	167.45	0.00	167.45	0.4667	0.00	-0.18	-0.001	16023.9	334.40	13802.8	320.46
6	20.189	23.000	166.68	166.68	0.00	166.68	0.4648	0.00	-0.19	-0.001	15998.3	333.94	13796.2	320.12
7	19.244	23.000	165.52	165.53	0.00	165.53	0.4617	0.00	-0.19	-0.001	15964.1	333.52	13793.0	319.89
8	18.303	23.000	164.03	164.03	0.00	164.03	0.4577	0.00	-0.17	-0.001	15920.9	333.14	13790.4	319.76
9	17.363	23.000	161.23	161.23	0.00	161.23	0.4495	0.00	-0.14	-0.001	15844.2	333.24	13792.6	320.30
10	16.411	23.000	156.34	156.34	0.00	156.34	0.4354	0.00	-0.10	-0.001	15700.8	333.15	13783.1	320.99
11	15.436	23.000	150.14	150.14	0.00	150.14	0.4175	0.00	-0.11	-0.001	15537.1	333.19	13780.9	321.99
HUB	15.240	23.000												

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PAGE NO. 19

*** COMPUTED COMPRESSOR DESIGN PARAMETERS FOR A ROTATIONAL SPEED OF, 16100.0, RPM ***

** THE CORRECTED WEIGHTFLOW PER UNIT OF CASING ANNULAR AREA AT THE INLET FACE OF THE FIRST BLADE ROW IS 148.78 KG SEC M*2 **

** MASS AVERAGED ROTOR AND STAGE AERODYNAMIC PARAMETERS **

STAGE NO.	BLADE TYPE	FLOW COEF.	HEAD COEF.	ID. HEAD COEF.	TOTAL PRESS RATIO	TOTAL TEMP. RATIO	ADIA. EFF.	POLY. EFF.	ASPECT RATIO	FOR. AX SHAFT THRUST (Kg)	GAS BENDING MOMENTS FOR EACH BLADE FOR. AX. (M-Kg)	TANG. (M-Kg)	TORQUE (M-Kg)	POWER (KW)
1	ROTOR	0.4654	0.2298	0.2579	1.6056	1.1626	0.8910	0.8980	2.54	448.10	0.862	-0.586	83.93	1387.[illegible]
1	STATOR	0.3906	0.2195	0.2579	1.5740	1.1626	0.8512	0.8604	2.43	-133.32	0.152	0.427		

** CUMULATIVE SUMS OF MASS AVERAGED ROTOR AND STAGE AERODYDAMIC PARAMETERS **

STAGE NO.	BLADE TYPE	WEIGHT FLOW (KG/SEC)	TOTAL PRESS. (KG/M*2)	TOTAL TEMP. (Deg K.)	TOTAL PRESS. RATIO	TOTAL TEMP. RATIO	HEAD COEF.	IDEAL HEAD COEF.	ADIA. EFF.	POLY. EFF.	FOR. AX. SHAFT THRUST (Kg)	TORQUE (M-Kg)	POWER (Kw)	FRACT ENERGY

1	INLET	29.48	10130.0	298.17							136.58	83.93	1387.77	1.0000
1	ROTOR	29.48	16264.7	335.02	1.6056	1.1626	0.2298	0.2579	0.8910	0.8980	95.94			
1	STATOR	29.48	15945.0	335.02	1.5740	1.1626	0.2195	0.2579	0.8512	0.8604				

First Stage Redesign of NASA 2 Stage - AR = 1.52

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** BLADE SECTION PROPERTIES OF ROTOR NO. 1 **

NUMBER OF BLADES = 44.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 2.050 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
1	25.350	2.3153	-0.0056	63.157	2.3297	0.0445	0.5467	0.00076	0.7648	63.566	0.00296	1.11284
2	25.150	2.3176	-0.0025	62.449	2.3311	0.0470	0.5586	0.00082	0.7774	62.798	0.00318	1.12892
3	24.400	2.3249	0.0028	60.416	2.3360	0.0496	0.6035	0.00105	0.8261	60.590	0.00408	1.19271
4	23.650	2.3298	0.0018	59.065	2.3391	0.0456	0.6477	0.00131	0.8742	59.133	0.00511	1.25585

SECTION NO. 1 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 2 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 3 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 4 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0260	0.0260	0.0000	0.0260	0.0260	0.0000	0.0259	0.0259	0.0000	0.0259	0.0258
0.0246	0.0000	0.0519	0.0244	0.0000	0.0519	0.0240	0.0001	0.0517	0.0238	0.0001	0.0516
0.0251	0.0000	0.0520	0.0252	0.0000	0.0519	0.0252	0.0000	0.0518	0.0249	0.0000	0.0517
0.2000	-0.0057	0.0609	0.2000	-0.0052	0.0619	0.2000	-0.0047	0.0642	0.2000	-0.0059	0.0649
0.4000	-0.0116	0.0703	0.4000	-0.0106	0.0724	0.4000	-0.0097	0.0772	0.4000	-0.0122	0.0787
0.6000	-0.0170	0.0788	0.6000	-0.0154	0.0819	0.6000	-0.0142	0.0889	0.6000	-0.0179	0.0912
0.8000	-0.0216	0.0864	0.8000	-0.0196	0.0904	0.8000	-0.0182	0.0993	0.8000	-0.0230	0.1022
1.0000	-0.0256	0.0932	1.0000	-0.0232	0.0979	1.0000	-0.0217	0.1085	1.0000	-0.0276	0.1118
1.2000	-0.0288	0.0992	1.2000	-0.0262	0.1045	1.2000	-0.0246	0.1165	1.2000	-0.0315	0.1202
1.4000	-0.0312	0.1044	1.4000	-0.0285	0.1102	1.4000	-0.0270	0.1232	1.4000	-0.0348	0.1271
1.6000	-0.0329	0.1088	1.6000	-0.0300	0.1150	1.6000	-0.0288	0.1288	1.6000	-0.0374	0.1329
1.8000	-0.0337	0.1126	1.8000	-0.0308	0.1190	1.8000	-0.0300	0.1331	1.8000	-0.0393	0.1371
2.0000	-0.0336	0.1157	2.0000	-0.0308	0.1222	2.0000	-0.0305	0.1364	2.0000	-0.0405	0.1402
2.2000	-0.0326	0.1183	2.2000	-0.0300	0.1246	2.2000	-0.0303	0.1385	2.2000	-0.0416	0.1420
2.4000	-0.0305	0.1203	2.4000	-0.0282	0.1264	2.4000	-0.0295	0.1395	2.4000	-0.0407	0.1426
2.6000	-0.0274	0.1219	2.6000	-0.0255	0.1276	2.6000	-0.0279	0.1395	2.6000	-0.0397	0.1419
2.8000	-0.0232	0.1231	2.8000	-0.0218	0.1282	2.8000	-0.0252	0.1387	2.8000	-0.0380	0.1401
3.0000	-0.0175	0.1243	3.0000	-0.0170	0.1284	3.0000	-0.0233	0.1363	3.0000	-0.0354	0.1370
3.2000	-0.0111	0.1248	3.2000	-0.0111	0.1282	3.2000	-0.0179	0.1339	3.2000	-0.0321	0.1328
3.4000	-0.0038	0.1247	3.4000	-0.0045	0.1272	3.4000	-0.0146	0.1299	3.4000	-0.0283	0.1270
3.6000	0.0033	0.1228	3.6000	0.0009	0.1234	3.6000	-0.0102	0.1227	3.6000	-0.0243	0.1196
3.8000	0.0068	0.1164	3.8000	0.0044	0.1165	3.8000	-0.0072	0.1144	3.8000	-0.0201	0.1104
4.0000	0.0090	0.1071	4.0000	0.0064	0.1066	4.0000	-0.0044	0.1034	4.0000	-0.0157	0.0996
4.2000	0.0089	0.0942	4.2000	0.0066	0.0935	4.2000	-0.0023	0.0903	4.2000	-0.0110	0.0870
4.4000	0.0065	0.0778	4.4000	0.0050	0.0772	4.4000	-0.0008	0.0749	4.4000	-0.0063	0.0727
4.6000	0.0018	0.0577	4.6000	0.0014	0.0575	4.6000	-0.0001	0.0571	4.6000	-0.0014	0.0566
4.6545	0.0000	0.0516	4.6540	0.0000	0.0516	4.6557	0.0000	0.0517	4.6577	0.0000	0.0517
4.6595	0.0002	0.0510	4.6586	0.0002	0.0511	4.6587	0.0002	0.0514	4.6595	0.0001	0.0515
4.6816	0.0256	0.0256	4.6809	0.0257	0.0257	4.6817	0.0258	0.0258	4.6830	0.0258	0.0258

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** BLADE SECTION PROPERTIES OF ROTOR NO. 1 **

NUMBER OF BLADES = 44.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 2.050 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
5	22.900	2.3326	-0.0007	57.994	2.3404	0.0401	0.6918	0.00160	0.9214	58.000	0.00632	1.31619
6	22.150	2.3355	0.0017	56.717	2.3419	0.0394	0.7361	0.00194	0.9693	56.681	0.00770	1.37726

7	21.400	2.3384	0.0092	55.198	2.3433	0.0439	0.7804	0.00235	1.0173	55.142	0.00928	1.43791
8	20.650	2.3413	0.0204	53.464	2.3448	0.0520	0.8248	0.00283	1.0652	53.399	0.01105	1.49929

SECTION NO. 5 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0237	0.0001	0.0516
0.0247	0.0000	0.0516
0.2000	-0.0076	0.0652
0.4000	-0.0157	0.0793
0.6000	-0.0231	0.0920
0.8000	-0.0297	0.1032
1.0000	-0.0357	0.1130
1.2000	-0.0408	0.1214
1.4000	-0.0452	0.1284
1.6000	-0.0488	0.1340
1.8000	-0.0515	0.1383
2.0000	-0.0534	0.1412
2.2000	-0.0545	0.1427
2.4000	-0.0546	0.1430
2.6000	-0.0539	0.1419
2.8000	-0.0522	0.1396
3.0000	-0.0497	0.1360
3.2000	-0.0463	0.1311
3.4000	-0.0421	0.1248
3.6000	-0.0372	0.1170
3.8000	-0.0316	0.1077
4.0000	-0.0254	0.0970
4.2000	-0.0184	0.0849
4.4000	-0.0108	0.0713
4.6000	-0.0025	0.0562
4.6579	0.0000	0.0516
4.6589	0.0001	0.0515
4.6826	0.0258	0.0258

SECTION NO. 6 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0236	0.0001	0.0516
0.0245	0.0000	0.0516
0.2000	-0.0085	0.0664
0.4000	-0.0175	0.0817
0.6000	-0.0257	0.0954
0.8000	-0.0332	0.1075
1.0000	-0.0399	0.1181
1.2000	-0.0457	0.1271
1.4000	-0.0507	0.1346
1.6000	-0.0548	0.1406
1.8000	-0.0581	0.1450
2.0000	-0.0604	0.1480
2.2000	-0.0619	0.1495
2.4000	-0.0623	0.1495
2.6000	-0.0619	0.1481
2.8000	-0.0604	0.1454
3.0000	-0.0579	0.1411
3.2000	-0.0544	0.1355
3.4000	-0.0501	0.1284
3.6000	-0.0447	0.1199
3.8000	-0.0384	0.1100
4.0000	-0.0311	0.0986
4.2000	-0.0228	0.0859
4.4000	-0.0135	0.0718
4.6000	-0.0031	0.0564
4.6579	0.0000	0.0517
4.6587	0.0001	0.0516
4.6824	0.0259	0.0259

SECTION NO. 7 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0234	0.0001	0.0515
0.0244	0.0000	0.0516
0.2000	-0.0085	0.0683
0.4000	-0.0176	0.0857
0.6000	-0.0259	0.1012
0.8000	-0.0335	0.1150
1.0000	-0.0402	0.1270
1.2000	-0.0462	0.1373
1.4000	-0.0512	0.1458
1.6000	-0.0555	0.1525
1.8000	-0.0589	0.1576
2.0000	-0.0614	0.1609
2.2000	-0.0629	0.1626
2.4000	-0.0636	0.1626
2.6000	-0.0633	0.1609
2.8000	-0.0620	0.1576
3.0000	-0.0596	0.1528
3.2000	-0.0564	0.1463
3.4000	-0.0520	0.1381
3.6000	-0.0467	0.1284
3.8000	-0.0403	0.1172
4.0000	-0.0327	0.1044
4.2000	-0.0241	0.0901
4.4000	-0.0143	0.0743
4.6000	-0.0033	0.0570
4.6576	0.0000	0.0518
4.6585	0.0001	0.0517
4.6820	0.0259	0.0259

SECTION NO. 8 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0230	0.0001	0.0515
0.0244	0.0000	0.0516
0.2000	-0.0080	0.0709
0.4000	-0.0164	0.0910
0.6000	-0.0242	0.1090
0.8000	-0.0312	0.1250
1.0000	-0.0375	0.1399
1.2000	-0.0431	0.1509
1.4000	-0.0479	0.1607
1.6000	-0.0519	0.1686
1.8000	-0.0552	0.1745
2.0000	-0.0576	0.1785
2.2000	-0.0592	0.1804
2.4000	-0.0599	0.1805
2.6000	-0.0599	0.1796
2.8000	-0.0587	0.1748
3.0000	-0.0567	0.1691
3.2000	-0.0538	0.1615
3.4000	-0.0499	0.1521
3.6000	-0.0448	0.1409
3.8000	-0.0388	0.1278
4.0000	-0.0316	0.1129
4.2000	-0.0233	0.0963
4.4000	-0.0139	0.0790
4.6000	-0.0032	0.0579
4.6572	0.0000	0.0519
4.6584	0.0001	0.0517
4.6816	0.0259	0.0259

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** BLADE SECTION PROPERTIES OF ROTOR NO. 1 **

NUMBER OF BLADES = 44.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 2.050 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
9	19.900	2.3440	0.0330	51.670	2.3463	0.0615	0.8688	0.00339	1.1130	51.611	0.01303	1.55794
10	19.150	2.3464	0.0484	49.760	2.3476	0.0737	0.9138	0.00406	1.1613	49.711	0.01528	1.61819
11	18.400	2.3486	0.0673	47.671	2.3488	0.0893	0.9587	0.00486	1.2096	47.641	0.01777	1.67786
12	17.650	2.3509	0.0902	45.385	2.3503	0.1090	1.0043	0.00587	1.2589	45.387	0.02055	1.73826

SECTION NO. 9 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0227	0.0002	0.0514
0.0245	0.0000	0.0516
0.2000	-0.0072	0.0737
0.4000	-0.0149	0.0966
0.6000	-0.0220	0.1172
0.8000	-0.0284	0.1356
1.0000	-0.0341	0.1516
1.2000	-0.0392	0.1653
1.4000	-0.0436	0.1767
1.6000	-0.0473	0.1858

SECTION NO. 10 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0223	0.0002	0.0513
0.0245	0.0000	0.0517
0.2000	-0.0061	0.0769
0.4000	-0.0125	0.1032
0.6000	-0.0184	0.1268
0.8000	-0.0238	0.1479
1.0000	-0.0286	0.1663
1.2000	-0.0329	0.1822
1.4000	-0.0366	0.1954
1.6000	-0.0397	0.2061

SECTION NO. 11 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0218	0.0003	0.0512
0.0247	0.0000	0.0517
0.2000	-0.0043	0.0807
0.4000	-0.0089	0.1110
0.6000	-0.0131	0.1382
0.8000	-0.0170	0.1625
1.0000	-0.0204	0.1839
1.2000	-0.0234	0.2022
1.4000	-0.0260	0.2176
1.6000	-0.0283	0.2301

SECTION NO. 12 COORDINATES

L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258
0.0213	0.0004	0.0511
0.0249	0.0000	0.0518
0.2000	0.0020	0.0852
0.4000	-0.0040	0.1201
0.6000	-0.0059	0.1516
0.8000	-0.0076	0.1798
1.0000	-0.0091	0.2045
1.2000	-0.0104	0.2259
1.4000	-0.0116	0.2439
1.6000	-0.0125	0.2585

1.8000	-0.0503	0.1927	1.8000	-0.0422	0.2141	1.8000	-0.0301	0.2396	1.8000	0.0134	0.2697
2.0000	-0.0525	0.1974	2.0000	-0.0441	0.2196	2.0000	-0.0315	0.2462	2.0000	0.0145	0.2776
2.2000	-0.0539	0.1997	2.2000	-0.0453	0.2226	2.2000	-0.0326	0.2497	2.2000	-0.0145	0.2822
2.4000	-0.0549	0.2001	2.4000	-0.0462	0.2229	2.4000	-0.0328	0.2506	2.4000	-0.0149	0.2831
2.6000	-0.0547	0.1980	2.6000	-0.0461	0.2208	2.6000	-0.0330	0.2482	2.6000	-0.0150	0.2809
2.8000	-0.0531	0.1925	2.8000	-0.0447	0.2166	2.8000	-0.0328	0.2428	2.8000	-0.0148	0.2751
3.0000	-0.0496	0.1883	3.0000	-0.0442	0.2087	3.0000	-0.0316	0.2348	3.0000	-0.0145	0.2659
3.2000	-0.0496	0.1786	3.2000	-0.0417	0.1991	3.2000	-0.0302	0.2236	3.2000	-0.0139	0.2531
3.4000	-0.0459	0.1679	3.4000	-0.0387	0.1868	3.4000	-0.0281	0.2094	3.4000	-0.0131	0.2369
3.6000	-0.0410	0.1551	3.6000	-0.0350	0.1720	3.6000	-0.0254	0.1923	3.6000	-0.0119	0.2170
3.8000	-0.0357	0.1400	3.8000	-0.0303	0.1546	3.8000	-0.0221	0.1722	3.8000	-0.0104	0.1936
4.0000	-0.0291	0.1229	4.0000	-0.0248	0.1347	4.0000	-0.0181	0.1491	4.0000	-0.0086	0.1665
4.2000	-0.0215	0.1036	4.2000	-0.0183	0.1124	4.2000	-0.0134	0.1229	4.2000	-0.0064	0.1358
4.4000	-0.0128	0.0823	4.4000	-0.0109	0.0875	4.4000	-0.0080	0.0937	4.4000	-0.0038	0.1014
4.6000	-0.0029	0.0589	4.6000	-0.0025	0.0602	4.6000	-0.0018	0.0615	4.6000	-0.0008	0.0631
4.6565	0.0000	0.0520	4.6551	0.0000	0.0522	4.6529	0.0000	0.0525	4.6497	0.0000	0.0530
4.6583	0.0002	0.0517	4.6577	0.0003	0.0518	4.6565	0.0004	0.0519	4.6546	0.0005	0.0520
4.6810	0.0260	0.0260	4.6800	0.0260	0.0260	4.6782	0.0261	0.0261	4.6755	0.0263	0.0263

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** BLADE SECTION PROPERTIES OF ROTOR NO. 1 **

NUMBER OF BLADES = 44.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 2.050 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	STACKING POINT COORDINATES H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	BLADE SECTION C.G. COORDINATES H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	MOMENTS OF INERTIA THROUGH C.G. IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
13	16.900	2.3532	0.1205	42.791	2.3520	0.1361	1.0509	0.00724	1.3090	42.857	0.02367	1.79950
14	16.150	2.3561	0.1636	39.695	2.3545	0.1758	1.0993	0.00929	1.3609	39.900	0.02721	1.85933
15	15.450	2.3580	0.2216	36.154	2.3563	0.2307	1.1461	0.01246	1.4088	36.530	0.03094	1.91304
16	14.750	2.3602	0.2816	32.260	2.3586	0.2876	1.1985	0.01684	1.4648	32.769	0.03541	1.98082

SECTION NO. 13 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 14 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 15 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 16 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0257	0.0257	0.0000	0.0257	0.0257	0.0000	0.0257	0.0257	0.0000	0.0257	0.0257
0.0206	0.0005	0.0510	0.0198	0.0007	0.0508	0.0187	0.0010	0.0504	0.0175	0.0013	0.0501
0.0253	0.0000	0.0520	0.0259	0.0000	0.0524	0.0267	0.0000	0.0531	0.0277	0.0001	0.0541
0.2000	0.0015	0.0909	0.2000	0.0068	0.0985	0.2000	0.0143	0.1085	0.2000	0.0227	0.1199
0.4000	0.0032	0.1317	0.4000	0.0142	0.1472	0.4000	0.0299	0.1675	0.4000	0.0475	0.1992
0.6000	0.0048	0.1686	0.6000	0.0212	0.1914	0.6000	0.0446	0.2211	0.6000	0.0706	0.2541
0.8000	0.0064	0.2016	0.8000	0.0277	0.2311	0.8000	0.0583	0.2695	0.8000	0.0920	0.3117
1.0000	0.0078	0.2308	1.0000	0.0337	0.2662	1.0000	0.0708	0.3125	1.0000	0.1115	0.3631
1.2000	0.0091	0.2561	1.2000	0.0391	0.2968	1.2000	0.0822	0.3502	1.2000	0.1289	0.4080
1.4000	0.0103	0.2775	1.4000	0.0439	0.3230	1.4000	0.0922	0.3825	1.4000	0.1441	0.4467
1.6000	0.0112	0.2950	1.6000	0.0480	0.3446	1.6000	0.1005	0.4093	1.6000	0.1573	0.4796
1.8000	0.0120	0.3086	1.8000	0.0513	0.3616	1.8000	0.1079	0.4313	1.8000	0.1675	0.5052
2.0000	0.0125	0.3183	2.0000	0.0539	0.3740	2.0000	0.1133	0.4473	2.0000	0.1757	0.5249
2.2000	0.0128	0.3240	2.2000	0.0557	0.3819	2.2000	0.1168	0.4574	2.2000	0.1814	0.5379
2.4000	0.0129	0.3258	2.4000	0.0567	0.3848	2.4000	0.1192	0.4621	2.4000	0.1845	0.5437
2.6000	0.0128	0.3236	2.6000	0.0568	0.3830	2.6000	0.1196	0.4608	2.6000	0.1849	0.5426
2.8000	0.0125	0.3172	2.8000	0.0562	0.3762	2.8000	0.1182	0.4534	2.8000	0.1825	0.5343
3.0000	0.0120	0.3067	3.0000	0.0546	0.3644	3.0000	0.1148	0.4397	3.0000	0.1770	0.5185
3.2000	0.0113	0.2921	3.2000	0.0520	0.3475	3.2000	0.1094	0.4195	3.2000	0.1683	0.4948
3.4000	0.0103	0.2731	3.4000	0.0485	0.3252	3.4000	0.1017	0.3926	3.4000	0.1562	0.4629
3.6000	0.0092	0.2499	3.6000	0.0440	0.2975	3.6000	0.0918	0.3585	3.6000	0.1406	0.4223
3.8000	0.0078	0.2222	3.8000	0.0382	0.2641	3.8000	0.0794	0.3170	3.8000	0.1212	0.3723
4.0000	0.0063	0.1900	4.0000	0.0311	0.2246	4.0000	0.0643	0.2674	4.0000	0.0978	0.3122
4.2000	0.0045	0.1531	4.2000	0.0228	0.1787	4.2000	0.0466	0.2093	4.2000	0.0700	0.2409
4.4000	0.0026	0.1114	4.4000	0.0131	0.1259	4.4000	0.0259	0.1418	4.4000	0.0376	0.1575
4.6000	0.0005	0.0647	4.6000	0.0020	0.0660	4.6000	0.0021	0.0641	4.5994	0.0003	0.0604
4.6437	0.0000	0.0538	4.6324	0.0000	0.0556	4.6152	0.0001	0.0577	4.6152	0.0026	0.0521
4.6504	0.0008	0.0522	4.6416	0.0012	0.0525	4.6277	0.0018	0.0524	4.6309	0.0274	0.0274

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4.6704	0.0265	0.0265	4.6695	0.0269	0.0269	4.6450	0.0271	0.0271

** BLADE SECTION PROPERTIES OF ROTOR NO. 1 **

NUMBER OF BLADES = 44.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 2.550 Cm

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	STACKING POINT COORDINATES H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	BLADE SECTION C.G. COORDINATES H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	MOMENTS OF INERTIA THROUGH C.G. IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
17	14.050	2.3621	0.3387	28.390	2.3611	0.3417	1.2563	0.02223	1.5263	28.987	0.04081	2.05619
18	13.350	2.3634	0.3859	24.867	2.3633	0.3860	1.3154	0.02789	1.5808	25.513	0.04715	2.11293
19	12.600	2.3624	0.4177	21.826	2.3637	0.4149	1.3714	0.03281	1.6073	22.517	0.05466	2.10636
20	13.310	2.3634	0.3881	24.683	2.3634	0.3881	1.3187	0.02819	1.5833	25.331	0.04754	2.11430

SECTION NO. 17 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 18 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 19 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 20 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0258	0.0258	0.0000	0.0259	0.0259	0.0000	0.0261	0.0261	0.0000	0.0259	0.0259
0.0165	0.0017	0.0498	0.0156	0.0021	0.0496	0.0151	0.0024	0.0498	0.0156	0.0022	0.0496
0.0288	0.0002	0.0555	0.0298	0.0003	0.0570	0.0307	0.0004	0.0586	0.0299	0.0003	0.0571
0.2000	0.0309	0.1314	0.2000	0.0379	0.1416	0.2000	0.0429	0.1494	0.2000	0.0383	0.1421
0.4000	0.0646	0.2128	0.4000	0.0792	0.2327	0.4000	0.0895	0.2475	0.4000	0.0799	0.2337
0.6000	0.0959	0.2868	0.6000	0.1172	0.3151	0.6000	0.1319	0.3361	0.6000	0.1182	0.3165
0.8000	0.1246	0.3533	0.8000	0.1516	0.3891	0.8000	0.1700	0.4156	0.8000	0.1529	0.3909
1.0000	0.1504	0.4124	1.0000	0.1826	0.4552	1.0000	0.2037	0.4862	1.0000	0.1841	0.4573
1.2000	0.1734	0.4645	1.2000	0.2096	0.5127	1.2000	0.2328	0.5483	1.2000	0.2113	0.5151
1.4000	0.1937	0.5096	1.4000	0.2322	0.5622	1.4000	0.2571	0.6020	1.4000	0.2342	0.5650
1.6000	0.2091	0.5461	1.6000	0.2524	0.6049	1.6000	0.2773	0.6466	1.6000	0.2542	0.6076
1.8000	0.2237	0.5772	1.8000	0.2675	0.6378	1.8000	0.2936	0.6821	1.8000	0.2696	0.6408
2.0000	0.2339	0.5997	2.0000	0.2794	0.6629	2.0000	0.3056	0.7087	2.0000	0.2814	0.6660
2.2000	0.2409	0.6145	2.2000	0.2872	0.6795	2.2000	0.3132	0.7262	2.2000	0.2893	0.6826
2.4000	0.2447	0.6217	2.4000	0.2909	0.6873	2.4000	0.3163	0.7343	2.4000	0.2930	0.6905
2.6000	0.2447	0.6207	2.6000	0.2904	0.6862	2.6000	0.3147	0.7330	2.6000	0.2924	0.6894
2.8000	0.2410	0.6114	2.8000	0.2853	0.6760	2.8000	0.3082	0.7217	2.8000	0.2872	0.6791
3.0000	0.2333	0.5934	3.0000	0.2756	0.6560	3.0000	0.2967	0.6999	3.0000	0.2774	0.6591
3.2000	0.2214	0.5664	3.2000	0.2609	0.6260	3.2000	0.2797	0.6670	3.2000	0.2626	0.6298
3.4000	0.2051	0.5297	3.4000	0.2409	0.5850	3.4000	0.2569	0.6220	3.4000	0.2424	0.5876
3.6000	0.1841	0.4827	3.6000	0.2154	0.5323	3.6000	0.2280	0.5637	3.6000	0.2167	0.5346
3.8000	0.1581	0.4245	3.8000	0.1839	0.4666	3.8000	0.1923	0.4904	3.8000	0.1850	0.4685
4.0000	0.1267	0.3541	4.0000	0.1460	0.3864	4.0000	0.1492	0.3998	4.0000	0.1467	0.3878
4.2000	0.0896	0.2699	4.2000	0.1010	0.2897	4.2000	0.0977	0.2882	4.2000	0.1013	0.2903
4.4000	0.0462	0.1703	4.4000	0.0483	0.1734	4.4000	0.0366	0.1500	4.4000	0.0481	0.1730
4.5831	0.0005	0.0633	4.5574	0.0007	0.0653	4.5027	0.0009	0.0656	4.5554	0.0008	0.0654
4.6018	0.0035	0.0514	4.5783	0.0043	0.0497	4.5247	0.0051	0.0461	4.5764	0.0043	0.0496
4.6159	0.0274	0.0274	4.5907	0.0270	0.0270	4.5349	0.0256	0.0256	4.5887	0.0270	0.0270

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 1 FOR XCUT OF 25.3500 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)	SECTION 2 FOR XCUT OF 25.1500 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)	SECTION 3 FOR XCUT OF 24.4000 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)
0.00	-1.0857	-2.0179	-1.0391	-2.0409	-1.1089	-2.0079	-1.0626	-2.0313	-1.1785	-1.9769	-1.1329	-2.0013
0.02	-1.0482	-1.9330	-0.9946	-1.9597	-1.0708	-1.9233	-1.0173	-1.9505	-1.1386	-1.8931	-1.0850	-1.9221
0.05	-0.9915	-1.8057	-0.9280	-1.8377	-1.0133	-1.7964	-0.9495	-1.8292	-1.0783	-1.7675	-1.0133	-1.8031
0.09	-0.9153	-1.6363	-0.8395	-1.6749	-0.9359	-1.6275	-0.8595	-1.6672	-0.9970	-1.6005	-0.9179	-1.6442
0.14	-0.8190	-1.4249	-0.7297	-1.4709	-0.8381	-1.4169	-0.7476	-1.4643	-0.8940	-1.3925	-0.7992	-1.4453
0.20	-0.7021	-1.1719	-0.5988	-1.2255	-0.7191	-1.1648	-0.6142	-1.2204	-0.7684	-1.1437	-0.6574	-1.2061
0.26	-0.5837	-0.9195	-0.4692	-0.9794	-0.5984	-0.9136	-0.4819	-0.9758	-0.6406	-0.8960	-0.5166	-0.9663
0.32	-0.4640	-0.6677	-0.3409	-0.7326	-0.4761	-0.6630	-0.3508	-0.7305	-0.5107	-0.6494	-0.3766	-0.7259

0.38	-0.3430	-0.4165	-0.2141	-0.4851	-0.3524	-0.4132	-0.2209	-0.4846	-0.3788	-0.4038	-0.2377	-0.4849
0.44	-0.2210	-0.1659	-0.0997	-0.2369	-0.2273	-0.1641	-0.0924	-0.2379	-0.2449	-0.1593	-0.0999	-0.2433
0.50	-0.0980	0.0842	0.0349	0.0123	-0.1010	0.0842	0.0346	0.0094	-0.1093	0.0842	0.0369	-0.0011
0.56	0.0258	0.3338	0.1568	0.2623	0.0263	0.3320	0.1600	0.2576	0.0282	0.3265	0.1723	0.2418
0.62	0.1502	0.5830	0.2765	0.5132	0.1545	0.5792	0.2835	0.5065	0.1673	0.5678	0.3065	0.4853
0.68	0.2748	0.8320	0.3941	0.7651	0.2834	0.8259	0.4052	0.7563	0.3079	0.8081	0.4392	0.7295
0.74	0.4006	1.0803	0.5102	1.0175	0.4137	1.0717	0.5256	1.0066	0.4507	1.0469	0.5712	0.9739
0.80	0.5315	1.3256	0.6292	1.2685	0.5488	1.3147	0.6484	1.2556	0.5970	1.2834	0.7040	1.2178
0.86	0.6680	1.5675	0.7516	1.5174	0.6889	1.5545	0.7739	1.5029	0.7467	1.5175	0.8376	1.4610
0.91	0.7859	1.7663	0.8563	1.7233	0.8094	1.7517	0.8808	1.7076	0.8742	1.7106	0.9496	1.6632
0.95	0.8831	1.9234	0.9418	1.8868	0.9084	1.9077	0.9677	1.8704	0.9780	1.8638	1.0397	1.8245
0.98	0.9576	2.0400	1.0071	2.0088	0.9841	2.0236	1.0339	1.9920	1.0568	1.9778	1.1077	1.9452
1.00	1.0081	2.1172	1.0512	2.0897	1.0353	2.1003	1.0785	2.0727	1.1099	2.0535	1.1531	2.0255
L.E. CIRCLE CENTER	(Cm.)		-1.0619	-2.0284			-1.0852	-2.0186			-1.1551	-1.9879
T.E. CIRCLE CENTER	(Cm.)		1.0291	2.1025			1.0563	2.0856			1.1308	2.0384

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 4 FOR XCUT OF 23.6500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 5 FOR XCUT OF 22.9000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 6 FOR XCUT OF 22.1500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.2282	-1.9524	-1.1833	-1.9779	-1.2680	-1.9302	-1.2239	-1.9567	-1.3104	-1.9053	-1.2669	-1.9329
0.02	-1.1868	-1.8694	-1.1330	-1.9001	-1.2253	-1.8480	-1.1714	-1.8805	-1.2664	-1.8238	-1.2124	-1.8581
0.05	-1.1241	-1.7451	-1.0578	-1.7834	-1.1605	-1.7249	-1.0929	-1.7659	-1.1997	-1.7018	-1.1308	-1.7458
0.09	-1.0396	-1.5798	-0.9577	-1.6275	-1.0733	-1.5612	-0.9886	-1.6129	-1.1098	-1.5397	-1.0225	-1.5957
0.14	-0.9325	-1.3740	-0.8331	-1.4321	-0.9626	-1.3574	-0.8588	-1.4210	-0.9957	-1.3379	-0.8878	-1.4075
0.20	-0.8017	-1.1280	-0.6845	-1.1971	-0.8275	-1.1139	-0.7042	-1.1900	-0.8563	-1.0970	-0.7273	-1.1806
0.26	-0.6686	-0.8832	-0.5368	-0.9614	-0.6900	-0.8717	-0.5507	-0.9580	-0.7143	-0.8575	-0.5679	-0.9528
0.32	-0.5332	-0.6396	-0.3902	-0.7249	-0.5502	-0.6308	-0.3984	-0.7252	-0.5697	-0.6195	-0.4099	-0.7240
0.38	-0.3956	-0.3972	-0.2446	-0.4877	-0.4080	-0.3911	-0.2475	-0.4914	-0.4225	-0.3629	-0.2531	-0.4941
0.44	-0.2558	-0.1560	-0.1002	-0.2498	-0.2636	-0.1529	-0.0978	-0.2568	-0.2729	-0.1479	-0.0978	-0.2632
0.50	-0.1139	0.0839	0.0430	-0.0112	-0.1170	0.0841	0.0504	-0.0212	-0.1208	0.0857	0.0560	-0.0312
0.56	0.0300	0.3225	0.1849	0.2281	0.0318	0.3197	0.1972	0.2153	0.0336	0.3177	0.2084	0.2018
0.62	0.1759	0.5599	0.3255	0.4682	0.1827	0.5539	0.3424	0.4527	0.1902	0.5481	0.3591	0.4359
0.68	0.3237	0.7960	0.4648	0.7090	0.3355	0.7867	0.4861	0.6910	0.3491	0.7770	0.5082	0.6710
0.74	0.4738	1.0305	0.6032	0.9501	0.4907	1.0180	0.6286	0.9300	0.5102	1.0043	0.6557	0.9071
0.80	0.6266	1.2631	0.7412	1.1914	0.6481	1.2475	0.7698	1.1696	0.6736	1.2298	0.8017	1.1441
0.86	0.7821	1.4937	0.8787	1.4328	0.8077	1.4754	0.9098	1.4097	0.8391	1.4537	0.9459	1.3920
0.91	0.9136	1.6844	0.9930	1.6339	0.9424	1.6640	1.0256	1.6103	0.9786	1.6390	1.0649	1.5909
0.95	1.0201	1.8359	1.0843	1.7948	1.0513	1.8140	1.1176	1.7710	1.0912	1.7863	1.1591	1.7405
0.98	1.1008	1.9489	1.1526	1.9155	1.1335	1.9260	1.1862	1.8917	1.1762	1.8964	1.2293	1.8605
1.00	1.1550	2.0239	1.1982	1.9959	1.1887	2.0004	1.2318	1.9722	1.2331	1.9695	1.2759	1.9406
L.E. CIRCLE CENTER	(Cm.)		-1.2050	-1.9638			-1.2451	-1.9421			-1.2877	-1.9176
T.E. CIRCLE CENTER	(Cm.)		1.1758	2.0087			1.2094	1.9849			1.2535	1.9536

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 7 FOR XCUT OF 21.4000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 8 FOR XCUT OF 20.6500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 9 FOR XCUT OF 19.9000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.3561	-1.8768	-1.3132	-1.9053	-1.4051	-1.8442	-1.3630	-1.8737	-1.4541	-1.8096	-1.4127	-1.8400
0.02	-1.3108	-1.7960	-1.2568	-1.8322	-1.3586	-1.7641	-1.3046	-1.8022	-1.4064	-1.7302	-1.3525	-1.7702
0.05	-1.2423	-1.6751	-1.1723	-1.7222	-1.2882	-1.6444	-1.2173	-1.6946	-1.3340	-1.6117	-1.2624	-1.6652
0.09	-1.1497	-1.5146	-1.0601	-1.5752	-1.1929	-1.4855	-1.1013	-1.5509	-1.2360	-1.4544	-1.1426	-1.5248

0.14	-1.0321	-1.3148	-0.9205	-1.3907	-1.0717	-1.2879	-0.9568	-1.3705	-1.1111	-1.2592	-0.9932	-1.3487
0.20	-0.8882	-1.0767	-0.7540	-1.1685	-0.9230	-1.0527	-0.7843	-1.1532	-0.9577	-1.0269	-0.8149	-1.1366
0.26	-0.7414	-0.8401	-0.5887	-0.9451	-0.7711	-0.8194	-0.6128	-0.9348	-0.8005	-0.7970	-0.6372	-0.9234
0.32	-0.5916	-0.6053	-0.4246	-0.7207	-0.6157	-0.5881	-0.4423	-0.7154	-0.6396	-0.5694	-0.4605	-0.7092
0.38	-0.4390	-0.3722	-0.2617	-0.4953	-0.4572	-0.3589	-0.2730	-0.4949	-0.4751	-0.3443	-0.2848	-0.4941
0.44	-0.2835	-0.1409	-0.1002	-0.2687	-0.2954	-0.1318	-0.1048	-0.2734	-0.3070	-0.1217	-0.1100	-0.2779
0.50	-0.1254	0.0887	0.0599	-0.0411	-0.1305	0.0931	0.0622	-0.0508	-0.1354	0.0983	0.0637	-0.0606
0.56	0.0354	0.3164	0.2186	0.1877	0.0375	0.3158	0.2278	0.1729	0.0397	0.3157	0.2363	0.1577
0.62	0.1988	0.5423	0.3757	0.4176	0.2084	0.5363	0.3921	0.3977	0.2181	0.5305	0.4077	0.3771
0.68	0.3647	0.7664	0.5312	0.6486	0.3822	0.7546	0.5550	0.6236	0.3998	0.7426	0.5779	0.5976
0.74	0.5331	0.9885	0.6851	0.8807	0.5588	0.9706	0.7163	0.8507	0.5847	0.9519	0.7467	0.8192
0.80	0.7038	1.2088	0.8373	1.1139	0.7381	1.1843	0.8759	1.0790	0.7727	1.1585	0.9140	1.0420
0.86	0.8769	1.4272	0.9876	1.3482	0.9201	1.3958	1.0338	1.3085	0.9637	1.3623	1.0798	1.2661
0.91	1.0229	1.6077	1.1115	1.5442	1.0736	1.5702	1.1640	1.5006	1.1251	1.5301	1.2167	1.4537
0.95	1.1407	1.7512	1.2097	1.7017	1.1977	1.7087	1.2673	1.6549	1.2557	1.6628	1.3253	1.6044
0.98	1.2297	1.8582	1.2827	1.8201	1.2915	1.8119	1.3441	1.7710	1.3544	1.7616	1.4063	1.7179
1.00	1.2893	1.9294	1.3311	1.8991	1.3543	1.8804	1.3950	1.9486	1.4206	1.9271	1.4600	1.7936
L.E. CIRCLE CENTER	(Cm.)		-1.3336	-1.8894			-1.3828	-1.8573			-1.4321	-1.8230
T.E. CIRCLE CENTER	(Cm.)		1.3091	1.9127			1.3733	1.8628			1.4398	1.8085

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 10 FOR XCUT OF 19.1500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 11 FOR XCUT OF 18.4000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 12 FOR XCUT OF 17.6500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.5036	-1.7722	-1.4630	-1.8036	-1.5550	-1.7310	-1.5152	-1.7633	-1.6083	-1.6858	-1.5694	-1.7191
0.02	-1.4547	-1.6936	-1.4010	-1.7355	-1.5049	-1.6531	-1.4516	-1.6970	-1.5570	-1.6086	-1.5042	-1.6545
0.05	-1.3804	-1.5762	-1.3083	-1.6331	-1.4287	-1.5368	-1.3563	-1.5972	-1.4789	-1.4934	-1.4064	-1.5575
0.09	-1.2797	-1.4206	-1.1848	-1.4962	-1.3253	-1.3829	-1.2293	-1.4640	-1.3727	-1.3412	-1.2760	-1.4280
0.14	-1.1511	-1.2277	-1.0309	-1.3246	-1.1930	-1.1923	-1.0708	-1.2970	-1.2367	-1.1531	-1.1131	-1.2659
0.20	-0.9929	-0.9985	-0.8467	-1.1178	-1.0299	-0.9665	-0.8809	-1.0959	-1.0685	-0.9307	-0.9176	-1.0709
0.26	-0.8306	-0.7721	-0.6631	-0.9101	-0.8621	-0.7438	-0.6914	-0.8941	-0.8952	-0.7120	-0.7222	-0.8754
0.32	-0.6640	-0.5485	-0.4802	-0.7016	-0.6897	-0.5244	-0.5023	-0.6917	-0.7166	-0.4972	-0.5268	-0.6795
0.38	-0.4934	-0.3278	-0.2980	-0.4921	-0.5127	-0.3085	-0.3135	-0.4885	-0.5330	-0.2865	-0.3314	-0.4832
0.44	-0.3188	-0.1100	-0.1166	-0.2817	-0.3312	-0.0961	-0.1252	-0.2846	-0.3443	-0.0800	-0.1360	-0.2865
0.50	-0.1402	0.1047	0.0640	-0.0704	-0.1453	0.1127	0.0626	-0.0799	-0.1506	0.1221	0.0593	-0.0894
0.56	0.0422	0.3163	0.2438	0.1419	0.0449	0.3176	0.2500	0.1255	0.0479	0.3196	0.2545	0.1082
0.62	0.2284	0.5247	0.4227	0.3552	0.2395	0.5187	0.4368	0.3317	0.2512	0.5124	0.4496	0.3062
0.68	0.4183	0.7298	0.6005	0.5695	0.4383	0.7158	0.6229	0.5387	0.4593	0.7003	0.6445	0.5047
0.74	0.6119	0.9316	0.7773	0.7848	0.6411	0.9088	0.8082	0.7466	0.6721	0.8831	0.8392	0.7039
0.80	0.8090	1.1300	0.9528	1.0013	0.8480	1.0977	0.9928	0.9553	0.8894	1.0607	1.0336	0.9034
0.86	1.0096	1.3250	1.1271	1.2188	1.0589	1.2822	1.1766	1.1650	1.1111	1.2330	1.2276	1.1035
0.91	1.1793	1.4849	1.2713	1.4010	1.2375	1.4327	1.3290	1.3405	1.2992	1.3723	1.3891	1.2709
0.95	1.3167	1.6110	1.3860	1.5474	1.3822	1.5509	1.4504	1.4815	1.4518	1.4809	1.5180	1.4049
0.98	1.4207	1.7046	1.4715	1.6575	1.4919	1.6382	1.5411	1.5875	1.5675	1.5606	1.6145	1.5057
1.00	1.4905	1.7665	1.5284	1.7311	1.5655	1.6958	1.6014	1.6593	1.6452	1.6130	1.6788	1.5731
L.E. CIRCLE CENTER	(Cm.)		-1.4818	-1.7861			-1.5335	-1.7452			-1.5871	-1.7004
T.E. CIRCLE CENTER	(Cm.)		1.5077	1.7470			1.5815	1.6752			1.6598	1.5912

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 13 FOR XCUT OF 16.9000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 14 FOR XCUT OF 16.1500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 15 FOR XCUT OF 15.4500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)

0.00	-1.6645	-1.6356	-1.6264	-1.6699	-1.7256	-1.5790	-1.6885	1.6142	-1.7979	1.5193	-1.7517	1.5542
0.02	-1.6120	-1.5591	-1.5598	-1.6071	-1.6720	-1.5030	-1.6206	1.5532	1.7333	1.4425	-1.6929	1.4946
0.05	-1.5320	-1.4450	-1.4597	-1.5129	-1.5902	-1.3899	-1.5185	-1.4616	-1.6499	-1.3299	-1.5791	-1.4052
0.09	-1.4231	-1.2944	-1.3262	-1.3872	-1.4785	-1.2408	-1.3821	-1.3397	-1.5357	-1.1618	-1.4404	-1.2965
0.14	-1.2832	-1.1087	-1.1591	-1.2390	-1.3348	-1.0574	-1.2111	-1.1875	-1.3882	-1.0001	-1.2662	-1.1387
0.20	-1.1099	-0.8898	-0.9583	-1.0413	-1.1561	-0.8419	-1.0051	-1.0053	-1.2043	-0.7876	-1.0557	-0.9627
0.26	-0.9308	-0.6752	-0.7571	-0.8525	-0.9709	-0.6317	-0.7982	-0.8238	-1.0129	-0.5914	-0.8435	-0.7881
0.32	-0.7459	-0.4653	-0.5555	-0.6638	-0.7791	-0.4271	-0.5902	-0.6429	-0.8140	-0.3921	-0.6295	-0.6154
0.38	-0.5553	-0.2603	-0.3534	-0.4752	-0.5808	-0.2284	-0.3811	-0.4629	-0.6078	-0.1900	-0.4135	-0.4447
0.44	-0.3590	-0.0604	-0.1508	-0.2866	-0.3761	-0.0360	-0.1708	-0.2838	-0.3942	-0.0059	-0.1955	-0.2761
0.50	-0.1571	0.1341	0.0524	-0.0982	-0.1651	0.1497	0.0407	-0.1056	-0.1733	0.1699	0.0245	-0.1099
0.56	0.0504	0.3230	0.2559	0.0901	0.0522	0.3283	0.2533	0.0715	0.0549	0.3363	0.2466	0.0540
0.62	0.2633	0.5060	0.4600	0.2784	0.2758	0.4994	0.4673	0.2476	0.2900	0.4929	0.4711	0.2151
0.68	0.4815	0.6828	0.6645	0.4665	0.5055	0.6625	0.6825	0.4224	0.5321	0.6390	0.6978	0.3732
0.74	0.7050	0.8532	0.8695	0.6544	0.7411	0.8172	0.8991	0.5960	0.7810	0.7737	0.9271	0.5290
0.80	0.9337	1.0169	1.0749	0.8423	0.9827	0.9629	1.1172	0.7681	1.0364	0.8962	1.1591	0.6793
0.86	1.1675	1.1737	1.2808	1.0300	1.2300	1.0991	1.3368	0.9383	1.2982	1.0055	1.3938	0.8266
0.91	1.3661	1.2987	1.4527	1.1863	1.4406	1.2044	1.5211	1.0787	1.5211	1.0857	1.5916	0.9461
0.95	1.5275	1.3950	1.5904	1.3113	1.6119	1.2832	1.6695	1.1901	1.7023	1.1421	1.7514	1.0394
0.98	1.6499	1.4649	1.6938	1.4051	1.7420	1.3389	1.7812	1.2730	1.8399	1.1799	1.8722	1.1079
1.00	1.7322	1.5104	1.7627	1.4676	1.8296	1.3743	1.8560	1.3280	1.9324	1.2025	1.9532	1.1529
L.E. CIRCLE CENTER	(Cm.)		-1.6436	-1.6507			-1.7050	-1.5945			-1.7676	-1.5341
T.E. CIRCLE CENTER	(Cm.)		1.7449	1.4871			1.8398	1.3495			1.9394	1.1762

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 16 FOR XCUT OF 14.7500 Cm.				SECTION 17 FOR XCUT OF 14.0500 Cm.				SECTION 18 FOR XCUT OF 13.3500 Cm.			
	SUCTION SURFACE		PRESSURE SURFACE		SUCTION SURFACE		PRESSURE SURFACE		SUCTION SURFACE		PRESSURE SURFACE	
	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)
0.00	-1.8574	-1.4462	-1.8221	-1.4830	-1.9262	-1.3694	-1.8918	-1.4072	-1.9887	-1.2923	1.9550	1.3311
0.02	-1.8016	-1.3706	-1.7522	-1.4247	-1.8690	-1.2941	-1.8207	-1.3503	-1.9298	-1.2172	-1.8927	1.2756
0.05	-1.7162	-1.2585	-1.6468	-1.3376	-1.7812	-1.1825	-1.7135	-1.2655	-1.8392	-1.1063	-1.7733	-1.1931
0.09	-1.5989	-1.1114	-1.5055	-1.2223	-1.6603	-1.0365	-1.5694	-1.1536	-1.7142	-0.9615	-1.6261	-1.0849
0.14	-1.4469	-0.9318	-1.3276	-1.0795	-1.5032	-0.8590	-1.3874	-1.0160	-1.5514	-0.7862	-1.4398	-0.9523
0.20	-1.2566	-0.7227	-1.1119	-0.9104	-1.3058	-0.6536	-1.1662	-0.8541	-1.3465	-0.5845	-1.2126	-0.7930
0.26	-1.0579	-0.5213	-0.8937	-0.7440	-1.0991	-0.4572	-0.9416	-0.6964	-1.1315	-0.3931	-0.9914	-0.6491
0.32	-0.8507	-0.3282	-0.6729	-0.5807	-0.8833	-0.2705	-0.7136	-0.5433	0.9069	[illegible]	0.7401	[illegible]
0.38	-0.6353	-0.1439	-0.4492	-0.4209	-0.6583	-0.0945	-0.4821	0.3956	[illegible]	[illegible]	[illegible]	[illegible]
0.44	-0.4117	0.0305	-0.2228	-0.2646	-0.4243	0.0696	-0.2473	0.2515	0.4284	[illegible]	[illegible]	[illegible]
0.50	-0.1799	0.1943	0.0064	-0.1121	-0.1816	0.2209	-0.0090	0.1133	[illegible]	[illegible]	[illegible]	[illegible]
0.56	0.0599	0.3466	0.2387	0.0364	0.0695	0.3583	0.2327	0.0192	[illegible]	[illegible]	[illegible]	[illegible]
0.62	0.3073	0.4865	0.4739	0.1804	0.3285	0.4807	0.4780	0.1455	0.3544	[illegible]	[illegible]	[illegible]
0.68	0.5622	0.6130	0.7124	0.3196	0.5950	0.5867	0.7269	0.2651	[illegible]	[illegible]	[illegible]	[illegible]
0.74	0.8241	0.7250	0.9543	0.4534	0.8681	0.6750	0.9795	0.3772	[illegible]	[illegible]	[illegible]	[illegible]
0.80	1.0927	0.8213	1.1996	0.5813	1.1473	0.7440	1.2356	0.4913	1.1959	[illegible]	1.2642	[illegible]
0.86	1.3676	0.9004	1.4484	0.7028	1.4315	0.7921	1.4953	0.5764	1.4934	[illegible]	[illegible]	[illegible]
0.91	1.6009	0.9522	1.6587	0.7987	1.6713	0.8148	1.7144	0.6483	1.7234	0.6941	1.7512	[illegible]
0.95	1.7901	0.9837	1.8287	0.8715	1.8645	0.8208	1.8914	0.7005	1.9146	[illegible]	[illegible]	[illegible]
0.98	1.9334	1.0011	1.9574	0.9238	2.0099	0.8179	2.0251	0.7363	2.0569	0.6450	2.0634	0.5612
1.00	2.0294	1.0096	2.0437	0.9574	2.1069	0.8122	2.1146	0.7586	2.1510	[illegible]	[illegible]	[illegible]
L.E. CIRCLE CENTER	(Cm.)		-1.8375	-1.4624			-1.9066	1.3861			-1.9694	[illegible]
T.E. CIRCLE CENTER	(Cm.)		2.0328	0.9825			2.1066	0.7849			[illegible]	0.5927

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** BLADE SECTION COORDINATES OF ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. SECTION 19 FOR XCUT OF 12.6000 Cm. SECTION 20 FOR XCUT OF 13.3100 Cm

OF SURF.	SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)	SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)
0.00	-2.0423	-1.2142	-2.0094	-1.2543	-1.9920	-1.2880	-1.9584	-1.3269
0.02	-1.9811	-1.1395	-1.9354	-1.2002	-1.9329	-1.2129	-1.8859	-1.2714
0.05	-1.8870	-1.0294	-1.8234	-1.1202	-1.8421	-1.1020	-1.7764	-1.1890
0.09	-1.7571	-0.8861	-1.6724	-1.0157	-1.7169	-0.9573	-1.6290	-1.0810
0.14	-1.5876	-0.7132	-1.4809	-0.8888	-1.5537	-0.7821	-1.4424	-0.9488
0.20	-1.3742	-0.5154	-1.2470	-0.7423	-1.3484	-0.5806	-1.2149	-0.7948
0.26	-1.1504	-0.3289	-1.0085	-0.6028	-1.1330	-0.3895	-0.9833	-0.6465
0.32	-0.9167	-0.1547	-0.7656	-0.4708	-0.9078	-0.2095	-0.7476	-0.5043
0.38	-0.6726	0.0049	-0.5191	-0.3454	-0.6728	-0.0421	-0.5081	-0.3681
0.44	-0.4192	0.1489	-0.2692	-0.2272	-0.4283	0.1113	-0.2650	-0.2380
0.50	-0.1572	0.2758	-0.0160	-0.1167	-0.1749	0.2496	-0.0182	-0.1146
0.56	0.1124	0.3843	0.2401	-0.0144	0.0868	0.3716	0.2321	0.0016
0.62	0.3882	0.4728	0.4987	0.0789	0.3561	0.4758	0.4858	0.1100
0.68	0.6688	0.5397	0.7593	0.1627	0.6319	0.5607	0.7428	0.2099
0.74	0.9524	0.5832	1.0211	0.2360	0.9131	0.6248	1.0029	0.3005
0.80	1.2366	0.6015	1.2833	0.2980	1.1984	0.6662	1.2656	0.3811
0.86	1.5185	0.5929	1.5447	0.3476	1.4859	0.6831	1.5305	0.4506
0.91	1.7491	0.5638	1.7608	0.3787	1.7257	0.6771	1.7526	0.4993
0.95	1.9290	0.5256	1.9317	0.3964	1.9165	0.6583	1.9307	0.5317
0.98	2.0601	0.4882	2.0584	0.4051	2.0584	0.6357	2.0644	0.5519
1.00	2.1454	0.4589	2.1418	0.4087	2.1522	0.6165	2.1535	0.5634
L.E. CIRCLE CENTER	(Cm.)		-2.0232	-1.2321			-1.9727	-1.3053
T.E. CIRCLE CENTER	(Cm.)		2.1388	0.4342			2.1483	0.5898

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** BLADE SECTION PROPERTIES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 **

PAGE NO. [illegible]

NUMBER OF BLADES = 48.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 9.499 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	STACKING POINT COORDINATES H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	BLADE SECTION C.G. COORDINATES H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	MOMENTS OF INERTIA THROUGH C.G. IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
1	25.150	2.0964	0.3669	12.627	2.0964	0.3669	0.8648	0.01519	0.8930	13.744	0.01545	1.00902
2	24.550	2.0924	0.3469	13.115	2.0924	0.3469	0.8780	0.01423	0.9055	14.183	0.01624	1.02201
3	23.950	2.0887	0.3324	13.546	2.0887	0.3324	0.8919	0.01367	0.9196	14.581	0.01707	1.03721
4	23.350	2.0853	0.3229	13.904	2.0853	0.3229	0.9066	0.01344	0.9349	14.921	0.01795	1.05427

SECTION NO. 1 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 2 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 3 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 4 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0254	0.0254	0.0000	0.0274	0.0274	0.0000	0.0293	0.0293	0.0000	0.0312	0.0312
0.0142	0.0026	0.0483	0.0158	0.0026	0.0522	0.0173	0.0026	0.0560	0.0187	0.0026	0.0598
0.0315	0.0007	0.0567	0.0334	0.0007	0.0603	0.0353	0.0006	0.0640	0.0373	0.0006	0.0679
0.2000	0.0413	0.1354	0.2000	0.0372	0.1343	0.2000	0.0341	0.1343	0.2000	0.0318	0.1354
0.4000	0.0866	0.2206	0.4000	0.0784	0.2154	0.4000	0.0723	0.2124	0.4000	0.0681	0.2115
0.6000	0.1288	0.2974	0.6000	0.1170	0.2885	0.6000	0.1081	0.2828	0.6000	0.1020	0.2801
0.8000	0.1680	0.3660	0.8000	0.1528	0.3539	0.8000	0.1414	0.3459	0.8000	0.1336	0.3416
1.0000	0.2042	0.4268	1.0000	0.1859	0.4118	1.0000	0.1723	0.4018	1.0000	0.1628	0.3961
1.2000	0.2374	0.4801	1.2000	0.2164	0.4626	1.2000	0.2007	0.4507	1.2000	0.1898	0.4438
1.4000	0.2677	0.5259	1.4000	0.2441	0.5063	1.4000	0.2266	0.4928	1.4000	0.2145	0.4849
1.6000	0.2950	0.5646	1.6000	0.2693	0.5431	1.6000	0.2502	0.5283	1.6000	0.2369	0.5195
1.8000	0.3187	0.5949	1.8000	0.2911	0.5720	1.8000	0.2706	0.5561	1.8000	0.2564	0.5466
2.0000	0.3349	0.6139	2.0000	0.3061	0.5899	2.0000	0.2847	0.5733	2.0000	0.2698	0.5634
2.2000	0.3432	0.6214	2.2000	0.3138	0.5969	2.2000	0.2919	0.5800	2.2000	0.2767	0.5697
2.4000	0.3436	0.6177	2.4000	0.3142	0.5931	2.4000	0.2923	0.5761	2.4000	0.2772	0.5658
2.6000	0.3362	0.6026	2.6000	0.3074	0.5784	2.6000	0.2860	0.5616	2.6000	0.2712	0.5515
2.8000	0.3208	0.5761	2.8000	0.2933	0.5527	2.8000	0.2728	0.5365	2.8000	0.2588	0.5267
3.0000	0.2975	0.5378	3.0000	0.2719	0.5158	3.0000	0.2529	0.5005	3.0000	0.2398	0.4913

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3.2000	0.2661	0.4874	3.2000	0.2430	0.4672	3.2000	0.2260	0.4533	3.2000	0.2143	0.4449
3.4000	0.2264	0.4243	3.4000	0.2067	0.4066	3.4000	0.1921	0.3945	3.4000	0.1821	0.3872
3.6000	0.1783	0.3477	3.6000	0.1626	0.3333	3.6000	0.1511	0.3234	3.6000	0.1432	0.3175
3.8000	0.1214	0.2568	3.8000	0.1107	0.2465	3.8000	0.1029	0.2394	3.8000	0.0975	0.2352
4.0000	0.0556	0.1503	4.0000	0.0508	0.1451	4.0000	0.0472	0.1415	4.0000	0.0447	0.1394
4.1458	0.0017	0.0618	4.1467	0.0014	0.0606	4.1474	0.0013	0.0597	4.1478	0.0011	0.0593
4.1689	0.0041	0.0468	4.1686	0.0038	0.0472	4.1683	0.0036	0.0474	4.1681	0.0034	0.0476
4.1804	0.0255	0.0255	4.1807	0.0255	0.0255	4.1808	0.0255	0.0255	4.1909	0.0255	0.0255

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** BLADE SECTION PROPERTIES OF STATOR NO. 1 FOLLOWING ROTOR NO 1 **

NUMBER OF BLADES = 48.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 9.400 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
5	22.750	2.0821	0.3182	14.151	2.0821	0.3182	0.9218	0.01350	0.9514	15.167	0.01886	1.07299
6	22.150	2.0791	0.3170	14.311	2.0791	0.3170	0.9374	0.01378	0.9687	15.338	0.01981	1.09301
7	21.575	2.0765	0.3183	14.554	2.0765	0.3183	0.9528	0.01423	0.9862	15.606	0.02077	1.11333
8	21.000	2.0741	0.3220	14.879	2.0741	0.3220	0.9686	0.01484	1.0042	15.960	0.02176	1.13459

SECTION NO. 5 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 6 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 7 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 8 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0331	0.0331	0.0000	0.0351	0.0351	0.0000	0.0369	0.0369	0.0000	0.0388	0.0398
0.0201	0.0027	0.0636	0.0213	0.0028	0.0674	0.0224	0.0030	0.0709	0.0235	0.0031	0.0744
0.0394	0.0006	0.0718	0.0416	0.0006	0.0759	0.0438	0.0006	0.0799	0.0461	0.0007	0.0840
0.2000	0.0304	0.1375	0.2000	0.0295	0.1402	0.2000	0.0291	0.1433	0.2000	0.0291	0.1469
0.4000	0.0655	0.2124	0.4000	0.0641	0.2147	0.4000	0.0636	0.2178	0.4000	0.0640	0.2219
0.6000	0.0983	0.2801	0.6000	0.0964	0.2820	0.6000	0.0959	0.2852	0.6000	0.0967	0.2898
0.8000	0.1289	0.3407	0.8000	0.1266	0.3423	0.8000	0.1260	0.3456	0.8000	0.1272	0.3507
1.0000	0.1573	0.3945	1.0000	0.1545	0.3958	1.0000	0.1540	0.3992	1.0000	0.1554	0.4047
1.2000	0.1834	0.4416	1.2000	0.1803	0.4427	1.2000	0.1797	0.4462	1.2000	0.1815	0.4522
1.4000	0.2074	0.4821	1.4000	0.2039	0.4831	1.4000	0.2033	0.4868	1.4000	0.2053	0.4932
1.6000	0.2291	0.5163	1.6000	0.2253	0.5171	1.6000	0.2247	0.5210	1.6000	0.2269	0.5277
1.8000	0.2480	0.5430	1.8000	0.2440	0.5438	1.8000	0.2434	0.5478	1.8000	0.2457	0.5549
2.0000	0.2611	0.5595	2.0000	0.2569	0.5602	2.0000	0.2563	0.5644	2.0000	0.2587	0.5716
2.2000	0.2678	0.5657	2.2000	0.2635	0.5664	2.2000	0.2630	0.5706	2.2000	0.2655	0.5779
2.4000	0.2683	0.5617	2.4000	0.2640	0.5624	2.4000	0.2635	0.5665	2.4000	0.2661	0.5739
2.6000	0.2625	0.5475	2.6000	0.2584	0.5481	2.6000	0.2579	0.5521	2.6000	0.2604	0.5592
2.8000	0.2505	0.5229	2.8000	0.2466	0.5234	2.8000	0.2462	0.5273	2.8000	0.2486	0.5341
3.0000	0.2321	0.4877	3.0000	0.2285	0.4882	3.0000	0.2282	0.4919	3.0000	0.2305	0.4983
3.2000	0.2074	0.4416	3.2000	0.2042	0.4421	3.2000	0.2040	0.4455	3.2000	0.2060	0.4513
3.4000	0.1763	0.3843	3.4000	0.1736	0.3847	3.4000	0.1734	0.3877	3.4000	0.1752	0.3928
3.6000	0.1386	0.3151	3.6000	0.1365	0.3155	3.6000	0.1364	0.3180	3.6000	0.1378	0.3221
3.8000	0.0944	0.2335	3.8000	0.0929	0.2338	3.8000	0.0929	0.2356	3.8000	0.0939	0.2386
4.0000	0.0433	0.1385	4.0000	0.0426	0.1387	4.0000	0.0427	0.1396	4.0000	0.0431	0.1412
4.1479	0.0011	0.0590	4.1480	0.0010	0.0590	4.1482	0.0010	0.0591	4.1481	0.0011	0.0594
4.1680	0.0034	0.0476	4.1680	0.0034	0.0476	4.1682	0.0035	0.0476	4.1684	0.0036	0.0475
4.1808	0.0255	0.0255	4.1807	0.0255	0.0255	4.1809	0.0255	0.0255	4.1809	0.0255	0.0255

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** BLADE SECTION PROPERTIES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 **

NUMBER OF BLADES = 48.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 9.400 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
9	20.425	2.0718	0.3261	15.202	2.0718	0.3261	0.9845	0.01549	1.0225	16.310	0.02279	1.15597
10	19.850	2.0697	0.3303	15.524	2.0697	0.3303	1.0005	0.01617	1.0408	16.660	0.02386	1.17741
11	19.275	2.0676	0.3343	15.849	2.0676	0.3343	1.0165	0.01687	1.0593	17.012	0.02497	1.19887
12	18.700	2.0657	0.3381	16.203	2.0657	0.3381	1.0327	0.01756	1.0777	17.392	0.02612	1.22035

SECTION NO. 9 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0406	0.0406
0.0245	0.0033	0.0779
0.0484	0.0007	0.0882
0.2000	0.0291	0.1506
0.4000	0.0646	0.2263
0.6000	0.0978	0.2948
0.8000	0.1287	0.3562
1.0000	0.1573	0.4108
1.2000	0.1837	0.4587
1.4000	0.2078	0.5000
1.6000	0.2296	0.5350
1.8000	0.2486	0.5624
2.0000	0.2617	0.5793
2.2000	0.2685	0.5857
2.4000	0.2691	0.5815
2.6000	0.2633	0.5668
2.8000	0.2513	0.5413
3.0000	0.2330	0.5050
3.2000	0.2083	0.4574
3.4000	0.1771	0.3981
3.6000	0.1394	0.3264
3.8000	0.0949	0.2416
4.0000	0.0436	0.1427
4.1480	0.0011	0.0596
4.1685	0.0037	0.0474
4.1809	0.0255	0.0255

SECTION NO. 10 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0425	0.0425
0.0255	0.0036	0.0815
0.0507	0.0008	0.0923
0.2000	0.0292	0.1543
0.4000	0.0652	0.2307
0.6000	0.0989	0.2998
0.8000	0.1303	0.3617
1.0000	0.1593	0.4168
1.2000	0.1860	0.4652
1.4000	0.2104	0.5070
1.6000	0.2324	0.5424
1.8000	0.2516	0.5701
2.0000	0.2648	0.5872
2.2000	0.2716	0.5936
2.4000	0.2722	0.5894
2.6000	0.2664	0.5745
2.8000	0.2543	0.5487
3.0000	0.2357	0.5119
3.2000	0.2107	0.4637
3.4000	0.1792	0.4036
3.6000	0.1410	0.3309
3.8000	0.0960	0.2448
4.0000	0.0441	0.1443
4.1478	0.0011	0.0599
4.1686	0.0038	0.0473
4.1808	0.0255	0.0255

SECTION NO. 11 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0444	0.0444
0.0265	0.0038	0.0850
0.0531	0.0009	0.0965
0.2000	0.0292	0.1580
0.4000	0.0658	0.2350
0.6000	0.0999	0.3047
0.8000	0.1317	0.3672
1.0000	0.1611	0.4228
1.2000	0.1881	0.4716
1.4000	0.2128	0.5138
1.6000	0.2350	0.5496
1.8000	0.2543	0.5776
2.0000	0.2677	0.5949
2.2000	0.2746	0.6014
2.4000	0.2751	0.5971
2.6000	0.2693	0.5820
2.8000	0.2570	0.5560
3.0000	0.2383	0.5187
3.2000	0.2130	0.4699
3.4000	0.1811	0.4090
3.6000	0.1425	0.3353
3.8000	0.0971	0.2480
4.0000	0.0445	0.1459
4.1477	0.0011	0.0602
4.1687	0.0039	0.0472
4.1808	0.0255	0.0255

SECTION NO. 12 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0462	0.0462
0.0275	0.0040	0.0885
0.0554	0.0009	0.1007
0.2000	0.0292	0.1616
0.4000	0.0662	0.2392
0.6000	0.1008	0.3094
0.8000	0.1329	0.3724
1.0000	0.1627	0.4285
1.2000	0.1900	0.4777
1.4000	0.2148	0.5203
1.6000	0.2373	0.5564
1.8000	0.2567	0.5848
2.0000	0.2702	0.6023
2.2000	0.2771	0.6098
2.4000	0.2777	0.6045
2.6000	0.2717	0.5992
2.8000	0.2593	0.5629
3.0000	0.2404	0.5252
3.2000	0.2150	0.4759
3.4000	0.1826	0.4141
3.6000	0.1439	0.3395
3.8000	0.0980	0.2510
4.0000	0.0450	0.1475
4.1476	0.0012	0.0605
4.1689	0.0040	0.0471
4.1808	0.0256	0.0256

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** BLADE SECTION PROPERTIES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 **

NUMBER OF BLADES = 48.0　　AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 9.400 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	STACKING POINT COORDINATES H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	BLADE SECTION C.G. COORDINATES H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
13	18.125	2.0639	0.3419	16.601	2.0639	0.3419	1.0489	0.01828	1.0964	17.821	0.02731	1.24198
14	17.550	2.0623	0.3468	17.088	2.0623	0.3468	1.0655	0.01912	1.1157	18.356	0.02855	1.26441
15	16.975	2.0608	0.3538	17.626	2.0608	0.3538	1.0825	0.02014	1.1356	18.941	0.02985	1.29765
16	16.400	2.0594	0.3607	18.135	2.0594	0.3607	1.0996	0.02120	1.1556	19.494	0.03119	1.31097

SECTION NO. 13 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0481	0.0481
0.0285	0.0042	0.0921
0.0578	0.0010	0.1049
0.2000	0.0291	0.1652
0.4000	0.0665	0.2433
0.6000	0.1015	0.3140
0.8000	0.1340	0.3775
1.0000	0.1640	0.4340
1.2000	0.1916	0.4837
1.4000	0.2167	0.5267
1.6000	0.2394	0.5632
1.8000	0.2591	0.5919
2.0000	0.2726	0.6096
2.2000	0.2797	0.6162
2.4000	0.2802	0.6119
2.6000	0.2743	0.5965

SECTION NO. 14 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0500	0.0500
0.0295	0.0044	0.0956
0.0602	0.0011	0.1092
0.2000	0.0291	0.1689
0.4000	0.0671	0.2477
0.6000	0.1026	0.3191
0.8000	0.1356	0.3832
1.0000	0.1662	0.4404
1.2000	0.1942	0.4907
1.4000	0.2198	0.5343
1.6000	0.2429	0.5713
1.8000	0.2629	0.6005
2.0000	0.2767	0.6186
2.2000	0.2840	0.6254
2.4000	0.2846	0.6211
2.6000	0.2787	0.6057

SECTION NO. 15 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0519	0.0519
0.0303	0.0047	0.0991
0.0627	0.0011	0.1137
0.2000	0.0294	0.1730
0.4000	0.0684	0.2530
0.6000	0.1048	0.3254
0.8000	0.1387	0.3905
1.0000	0.1700	0.4485
1.2000	0.1988	0.4997
1.4000	0.2250	0.5441
1.6000	0.2486	0.5818
1.8000	0.2691	0.6116
2.0000	0.2832	0.6300
2.2000	0.2907	0.6371
2.4000	0.2914	0.6328
2.6000	0.2853	0.6172

SECTION NO. 16 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0538	0.0538
0.0312	0.0050	0.1026
0.0653	0.0012	0.1181
0.2000	0.0297	0.1773
0.4000	0.0698	0.2584
0.6000	0.1072	0.3319
0.8000	0.1420	0.3980
1.0000	0.1741	0.4569
1.2000	0.2036	0.5089
1.4000	0.2303	0.5540
1.6000	0.2545	0.5924
1.8000	0.2753	0.6227
2.0000	0.2898	0.6415
2.2000	0.2973	0.6487
2.4000	0.2980	0.6445
2.6000	0.2918	0.6286

2.8000	0.2618	0.5699	2.8000	0.2661	0.5788	2.8000	0.2725	0.5899	2.8000	0.2787	0.6010
3.0000	0.2428	0.5318	3.0000	0.2469	0.5403	3.0000	0.2528	0.5508	3.0000	0.2586	0.5613
3.2000	0.2171	0.4819	3.2000	0.2208	0.4897	3.2000	0.2261	0.4993	3.2000	0.2314	0.5090
3.4000	0.1846	0.4195	3.4000	0.1879	0.4265	3.4000	0.1925	0.4349	3.4000	0.1970	0.4434
3.6000	0.1453	0.3439	3.6000	0.1480	0.3497	3.6000	0.1516	0.3566	3.6000	0.1551	0.3636
3.8000	0.0990	0.2542	3.8000	0.1008	0.2585	3.8000	0.1033	0.2635	3.8000	0.1057	0.2685
4.0000	0.0454	0.1492	4.0000	0.0463	0.1514	4.0000	0.0474	0.1539	4.0000	0.0464	0.1564
4.1475	0.0012	0.0608	4.1474	0.0012	0.0612	4.1469	0.0013	0.0618	4.1464	0.0014	0.0624
4.1691	0.0041	0.0471	4.1694	0.0042	0.0469	4.1693	0.0044	0.0468	4.1692	0.0046	0.0467
4.1808	0.0256	0.0256	4.1809	0.0256	0.0256	4.1806	0.0256	0.0256	4.1802	0.0256	0.0256

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** BLADE SECTION PROPERTIES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 **

NUMBER OF BLADES = 48.0 AXIAL LOCATION OF STACKING LINE IN COMPRESSOR = 9.450 Cm.

BLADE SECTION NO.	RAD. LOC. (Cm.)	STACKING POINT COORDINATES L (Cm.)	STACKING POINT COORDINATES H (Cm.)	SECTION SETTING ANGLE (DEG.)	BLADE SECTION C.G. COORDINATES L (Cm.)	BLADE SECTION C.G. COORDINATES H (Cm.)	SECTION AREA (Cm.)*2	MOMENTS OF INERTIA THROUGH C.G. IMIN (Cm.)*4	MOMENTS OF INERTIA THROUGH C.G. IMAX (Cm.)*4	IMAX SETTING ANGLE (DEG.)	SECTION TORSION CONSTANT (Cm.)*4	SECTION TWIST STIFFNESS (Cm.)*6
17	15.825	2.0582	0.3679	18.647	2.0582	0.3679	1.1171	0.02233	1.1762	20.964	0.03259	1.33485
18	15.250	2.0572	0.3765	19.201	2.0572	0.3765	1.1350	0.02364	1.1977	20.691	0.03406	1.35993
19	14.675	2.0566	0.3871	19.827	2.0566	0.3871	1.1537	0.02518	1.2205	21.410	0.03560	1.38709
20	25.145	2.0963	0.3667	12.631	2.0963	0.3667	0.8649	0.01518	0.8931	13.749	0.01545	1.00911

SECTION NO. 17 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 18 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 19 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)	SECTION NO. 20 COORDINATES L (Cm.)	HP (Cm.)	HS (Cm.)
0.0000	0.0557	0.0557	0.0000	0.0576	0.0576	0.0000	0.0596	0.0596	0.0000	0.0255	0.0255
0.0320	0.0053	0.1061	0.0328	0.0056	0.1096	0.0335	0.0060	0.1132	0.0143	0.0026	0.0483
0.0679	0.0013	0.1227	0.0706	0.0015	0.1273	0.0734	0.0016	0.1322	0.0316	0.0007	0.0568
0.2000	0.0300	0.1815	0.2000	0.0304	0.1858	0.2000	0.0308	0.1904	0.2000	0.0413	0.1354
0.4000	0.0711	0.2638	0.4000	0.0727	0.2695	0.4000	0.0747	0.2758	0.4000	0.0865	0.2206
0.6000	0.1095	0.3384	0.6000	0.1122	0.3454	0.6000	0.1156	0.3532	0.6000	0.1287	0.2973
0.8000	0.1452	0.4055	0.8000	0.1490	0.4137	0.8000	0.1537	0.4230	0.8000	0.1679	0.3659
1.0000	0.1782	0.4654	1.0000	0.1829	0.4747	1.0000	0.1890	0.4854	1.0000	0.2040	0.4267
1.2000	0.2084	0.5182	1.2000	0.2141	0.5286	1.2000	0.2213	0.5406	1.2000	0.2372	0.4799
1.4000	0.2358	0.5641	1.4000	0.2424	0.5755	1.4000	0.2507	0.5887	1.4000	0.2675	0.5257
1.6000	0.2606	0.6033	1.6000	0.2679	0.6156	1.6000	0.2773	0.6300	1.6000	0.2948	0.5644
1.8000	0.2819	0.6343	1.8000	0.2900	0.6474	1.8000	0.3002	0.6628	1.8000	0.3184	0.5947
2.0000	0.2968	0.6535	2.0000	0.3053	0.6672	2.0000	0.3163	0.6833	2.0000	0.3346	0.6136
2.2000	0.3045	0.6610	2.2000	0.3135	0.6750	2.2000	0.3249	0.6917	2.2000	0.3429	0.6212
2.4000	0.3053	0.6568	2.4000	0.3144	0.6710	2.4000	0.3261	0.6878	2.4000	0.3434	0.6175
2.6000	0.2991	0.6409	2.6000	0.3081	0.6549	2.6000	0.3198	0.6717	2.6000	0.3359	0.6024
2.8000	0.2857	0.6129	2.8000	0.2945	0.6266	2.8000	0.3059	0.6431	2.8000	0.3206	0.5759
3.0000	0.2652	0.5726	3.0000	0.2735	0.5857	3.0000	0.2843	0.6015	3.0000	0.2973	0.5376
3.2000	0.2374	0.5194	3.2000	0.2450	0.5316	3.2000	0.2548	0.5463	3.2000	0.2659	0.4872
3.4000	0.2022	0.4526	3.4000	0.2087	0.4635	3.4000	0.2173	0.4767	3.4000	0.2262	0.4241
3.6000	0.1593	0.3713	3.6000	0.1645	0.3803	3.6000	0.1715	0.3915	3.6000	0.1781	0.3476
3.8000	0.1085	0.2741	3.8000	0.1122	0.2807	3.8000	0.1170	0.2889	3.8000	0.1213	0.2567
4.0000	0.0497	0.1592	4.0000	0.0513	0.1626	4.0000	0.0534	0.1669	4.0000	0.0555	0.1502
4.1457	0.0014	0.0630	4.1450	0.0015	0.0639	4.1444	0.0017	0.0649	4.1458	0.0017	0.0618
4.1692	0.0048	0.0465	4.1691	0.0051	0.0463	4.1692	0.0054	0.0461	4.1689	0.0041	0.0469
4.1799	0.0257	0.0257	4.1795	0.0257	0.0257	4.1792	0.0257	0.0257	4.1804	0.0255	0.0255

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 1 FOR XCUT OF 25.1500 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)	SECTION 2 FOR XCUT OF 24.5500 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)	SECTION 3 FOR XCUT OF 23.9500 Cm. SUCTION SURFACE Z (Cm.)	SUCTION SURFACE Y (Cm.)	PRESSURE SURFACE Z (Cm.)	PRESSURE SURFACE Y (Cm.)
0.00	-1.9621	-0.7661	-1.9348	-0.8087	-1.9556	-0.7582	-1.9268	-0.8044	-1.9491	-0.7538	-1.9186	-0.8035

0.02	-1.8937	-0.7120	-1.8598	-0.7715	-1.8869	-0.7052	-1.8515	-0.7683	-1.8802	-0.7015	-1.8432	-0.7691
0.05	-1.7897	-0.6329	-1.7468	-0.7166	-1.7925	-0.6275	-1.7382	-0.7149	-1.7756	-0.6248	1.7299	-0.7156
0.09	-1.6483	-0.5309	-1.5953	-0.6450	-1.6408	-0.5273	-1.5865	-0.6451	-1.6338	-0.5258	-1.5790	-0.6471
0.14	-1.4674	-0.4094	-1.4049	-0.5580	-1.4597	-0.4079	-1.3958	-0.5601	-1.4528	-0.4076	-1.3872	-0.5634
0.20	-1.2447	-0.2725	-1.1747	-0.4574	-1.2371	-0.2730	-1.1655	-0.4616	-1.2304	-0.2739	-1.1570	-0.4662
0.26	-1.0162	-0.1455	-0.9427	-0.3610	-1.0090	-0.1477	-0.9337	-0.3669	-1.0028	-0.1495	-0.9253	-0.3724
0.32	-0.7823	-0.0287	-0.7091	-0.2687	-0.7759	-0.0321	-0.7003	-0.2758	-0.7702	-0.0345	-0.6923	-0.2821
0.38	-0.5436	0.0777	-0.4738	-0.1806	-0.5380	0.0736	-0.4655	-0.1886	-0.5332	0.0709	-0.4580	-0.1952
0.44	-0.2996	0.1715	-0.2365	-0.0981	-0.2952	0.1672	-0.2289	-0.1064	-0.2914	0.1648	-0.2220	-0.1130
0.50	-0.0495	0.2474	0.0043	-0.0268	-0.0465	0.2438	0.0110	-0.0346	-0.0438	0.2422	0.0171	-0.0405
0.56	0.2055	0.3046	0.2484	0.0325	0.2069	0.3027	0.2539	0.0263	0.2084	0.3025	0.2591	0.0219
0.62	0.4641	0.3429	0.4952	0.0796	0.4639	0.3435	0.4994	0.0760	0.4642	0.3455	0.5035	0.0738
0.68	0.7248	0.3620	0.7439	0.1145	0.7231	0.3661	0.7468	0.1146	0.7223	0.3710	0.7499	0.1155
0.74	0.9862	0.3618	0.9941	0.1371	0.9833	0.3704	0.9957	0.1420	0.9815	0.3788	0.9978	0.1466
0.80	1.2468	0.3424	1.2451	0.1472	1.2431	0.3565	1.2456	0.1580	1.2407	0.3690	1.2468	0.1673
0.86	1.5053	0.3038	1.4962	0.1450	1.5012	0.3242	1.4960	0.1627	1.4985	0.3416	1.4964	0.1775
0.91	1.7181	0.2572	1.7053	0.1337	1.7142	0.2836	1.7046	0.1580	1.7116	0.3054	1.7047	0.1779
0.95	1.8860	0.2105	1.8721	0.1184	1.8826	0.2421	1.8713	0.1486	1.8803	0.2678	1.8711	0.1730
0.98	2.0104	0.1701	1.9968	0.1034	2.0075	0.2058	1.9961	0.1382	2.0056	0.2346	1.9959	0.1663
1.00	2.0924	0.1407	2.0797	0.0916	2.0900	0.1792	2.0791	0.1297	2.0885	0.2101	2.0790	0.1603
L.E. CIRCLE CENTER	(Cm.)		-1.9462	-0.7859			-1.9387	-0.7798			-1.9312	-0.7770
T.E. CIRCLE CENTER	(Cm.)		2.0835	0.1168			2.0819	0.1551			2.0810	0.1857

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 4 FOR XCUT OF 23.3500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 5 FOR XCUT OF 22.7500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 6 FOR XCUT OF 22.1500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.9428	-0.7520	-1.9106	-0.8050	-1.9371	-0.7510	-1.9030	-0.8074	-1.9322	-0.7505	-1.8961	-0.8102
0.02	-1.8739	-0.7000	-1.8351	-0.7700	-1.8683	-0.6992	-1.8276	-0.7726	-1.8634	-0.6987	-1.8208	-0.7754
0.05	-1.7693	-0.6238	-1.7217	-0.7181	-1.7637	-0.6233	-1.7142	-0.7210	-1.7589	-0.6228	-1.7075	-0.7238
0.09	-1.6275	-0.5255	-1.5698	-0.6502	-1.6220	-0.5252	-1.5625	-0.6534	-1.6173	-0.5246	-1.5559	-0.6563
0.14	-1.4466	-0.4079	-1.3792	-0.5673	-1.4413	-0.4078	-1.3720	-0.5708	-1.4369	-0.4072	-1.3656	-0.5737
0.20	-1.2245	-0.2749	-1.1491	-0.4708	-1.2195	-0.2749	-1.1422	-0.4745	-1.2154	-0.2741	-1.1360	-0.4773
0.26	-0.9973	-0.1508	-0.9178	-0.3774	-0.9927	-0.1508	-0.9111	-0.3812	-0.9888	-0.1498	-0.9052	-0.3840
0.32	-0.7654	-0.0359	-0.6851	-0.2873	-0.7612	-0.0357	-0.6787	-0.2911	-0.7576	-0.0343	-0.6731	-0.2938
0.38	-0.5290	0.0697	-0.4512	-0.2004	-0.5253	0.0702	-0.4452	-0.2041	-0.5220	0.0720	-0.4399	0.2066
0.44	-0.2880	0.1640	-0.2157	-0.1181	-0.2847	0.1649	-0.2101	-0.1215	-0.2818	0.1672	-0.2051	-0.1237
0.50	-0.0412	0.2422	0.0227	-0.0448	-0.0385	0.2438	0.0279	-0.0478	-0.0358	0.2466	0.0326	-0.0495
0.56	0.2102	0.3036	0.2640	0.0188	0.2123	0.3062	0.2686	0.0167	0.2148	0.3096	0.2729	0.0155
0.62	0.4651	0.3485	0.5076	0.0726	0.4668	0.3520	0.5116	0.0717	0.4690	0.3559	0.5156	0.0712
0.68	0.7224	0.3761	0.7531	0.1166	0.7237	0.3808	0.7566	0.1172	0.7257	0.3854	0.7602	0.1177
0.74	0.9810	0.3865	1.0003	0.1507	0.9819	0.3927	1.0032	0.1532	0.9838	0.3978	1.0064	0.1547
0.80	1.2397	0.3796	1.2485	0.1748	1.2403	0.3874	1.2509	0.1795	1.2422	0.3932	1.2538	0.1822
0.86	1.4973	0.3555	1.4976	0.1890	1.4978	0.3652	1.4996	0.1962	1.4996	0.3716	1.5021	0.2003
0.91	1.7104	0.3224	1.7054	0.1932	1.7109	0.3336	1.7071	0.2027	1.7127	0.3406	1.7095	0.2080
0.95	1.8793	0.2874	1.8717	0.1915	1.8799	0.3000	1.8732	0.2031	1.8817	0.3073	1.8754	0.2094
0.98	2.0049	0.2563	1.9964	0.1874	2.0055	0.2699	1.9977	0.2006	2.0074	0.2775	1.9999	0.2077
1.00	2.0880	0.2332	2.0794	0.1832	2.0888	0.2476	2.0807	0.1975	2.0906	0.2553	2.0828	0.2053
L.E. CIRCLE CENTER	(Cm.)		-1.9238	-0.7767			-1.9170	-0.7774			-1.9109	-0.7784
T.E. CIRCLE CENTER	(Cm.)		2.0809	0.2087			2.0818	0.2230			2.0838	0.2308

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF	SECTION 7 FOR XCUT OF 21.5750 Cm. SUCTION SURFACE		PRESSURE SURFACE		SECTION 8 FOR XCUT OF 21.0000 Cm. SUCTION SURFACE		PRESSURE SURFACE		SECTION 9 FOR XCUT OF 20.4250 Cm. SUCTION SURFACE		PRESSURE SURFACE	

SURF.	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)	Z (Cm.)	Y (Cm.)
0.00	-1.9260	-0.7556	-1.8877	-0.8182	-1.9183	-0.7658	-1.8776	-0.8313	-1.9106	-0.7763	-1.8673	-0.8446
0.02	-1.8574	-0.7036	-1.8126	-0.7832	-1.8501	-0.7132	-1.8027	-0.7957	-1.8428	-0.7231	-1.7928	-0.8083
0.05	-1.7533	-0.6272	-1.6995	-0.7313	-1.7465	-0.6360	-1.6902	-0.7429	-1.7398	-0.6449	-1.6807	-0.7546
0.09	-1.6121	-0.5285	-1.5483	-0.6631	-1.6061	-0.5361	-1.5395	-0.6736	-1.6001	-0.5438	-1.5307	-0.6842
0.14	-1.4321	-0.4102	-1.3584	-0.5798	-1.4270	-0.4164	-1.3504	-0.5890	-1.4219	-0.4226	-1.3423	-0.5981
0.20	-1.2112	-0.2761	-1.1294	-0.4826	-1.2070	-0.2805	-1.1221	-0.4901	-1.2028	-0.2848	-1.1149	-0.4975
0.26	-0.9853	-0.1507	-0.8991	-0.3884	-0.9818	-0.1533	-0.8926	-0.3943	-0.9785	-0.1558	-0.8861	-0.4001
0.32	-0.7545	-0.0341	-0.6675	-0.2973	-0.7518	-0.0349	-0.6617	-0.3016	-0.7492	-0.0356	-0.6560	-0.3058
0.38	-0.5195	0.0734	-0.4348	-0.2092	-0.5173	0.0743	-0.4296	-0.2120	-0.5154	0.0755	-0.4246	-0.2147
0.44	-0.2796	0.1697	-0.2005	-0.1254	-0.2780	0.1724	-0.1959	-0.1268	-0.2765	0.1753	-0.1915	-0.1281
0.50	-0.0339	0.2502	0.0368	-0.0502	-0.0327	0.2544	0.0408	-0.0503	-0.0315	0.2588	0.0447	-0.0502
0.56	0.2165	0.3142	0.2767	0.0158	0.2176	0.3198	0.2803	0.0171	0.2186	0.3255	0.2837	0.0184
0.62	0.4706	0.3615	0.5190	0.0726	0.4717	0.3682	0.5222	0.0751	0.4727	0.3750	0.5252	0.0777
0.68	0.7273	0.3917	0.7633	0.1201	0.7284	0.3994	0.7662	0.1238	0.7295	0.4071	0.7689	0.1276
0.74	0.9854	0.4049	1.0092	0.1582	0.9867	0.4133	1.0118	0.1631	0.9879	0.4217	1.0143	0.1679
0.80	1.2438	0.4008	1.2564	0.1868	1.2453	0.4097	1.2588	0.1928	1.2467	0.4185	1.2611	0.1986
0.86	1.5014	0.3795	1.5045	0.2060	1.5030	0.3887	1.5067	0.2129	1.5046	0.3977	1.5088	0.2196
0.91	1.7145	0.3488	1.7117	0.2146	1.7163	0.3580	1.7138	0.2223	1.7180	0.3669	1.7158	0.2297
0.95	1.8836	0.3156	1.8775	0.2168	1.8855	0.3247	1.8796	0.2250	1.8873	0.3335	1.8815	0.2329
0.98	2.0093	0.2858	2.0020	0.2157	2.0113	0.2948	2.0040	0.2242	2.0131	0.3033	2.0059	0.2324
1.00	2.0926	0.2636	2.0849	0.2136	2.0945	0.2725	2.0869	0.2224	2.0964	0.2809	2.0887	0.2308
L.E. CIRCLE CENTER	(Cm.)		-1.9035	-0.7848			-1.8944	-0.7963			-1.8853	-0.8081
T.E. CIRCLE CENTER	(Cm.)		2.0857	0.2391			2.0876	0.2479			2.0894	0.2563

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 10 FOR XCUT OF 19.8500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 11 FOR XCUT OF 19.2750 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 12 FOR XCUT OF 18.7000 Cm SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.9030	-0.7869	-1.8571	-0.8578	-1.8954	-0.7973	-1.8469	-0.8710	-1.8876	-0.8084	-1.8363	-0.8848
0.02	-1.8356	-0.7330	-1.7829	-0.8210	-1.8285	-0.7429	-1.7731	-0.8335	-1.8210	-0.7534	-1.7629	-0.8467
0.05	-1.7332	-0.6539	-1.6713	-0.7664	-1.7267	-0.6628	-1.6620	-0.7780	-1.7199	-0.6724	-1.6523	-0.7903
0.09	-1.5943	-0.5516	-1.5220	-0.6948	-1.5885	-0.5593	-1.5132	-0.7052	-1.5825	-0.5676	-1.5042	-0.7163
0.14	-1.4169	-0.4288	-1.3343	-0.6072	-1.4120	-0.4350	-1.3264	-0.6162	-1.4069	-0.4417	-1.3182	-0.6258
0.20	-1.1988	-0.2892	-1.1078	-0.5049	-1.1948	-0.2935	-1.1007	-0.5123	-1.1908	-0.2984	-1.0934	-0.5202
0.26	-0.9753	-0.1582	-0.8798	-0.4059	-0.9722	-0.1608	-0.8735	-0.4116	-0.9691	-0.1638	-0.8671	-0.4178
0.32	-0.7468	-0.0362	-0.6504	-0.3100	-0.7444	-0.0369	-0.6449	-0.3142	-0.7422	-0.0380	-0.6393	-0.3169
0.38	-0.5136	0.0767	-0.4197	-0.2174	-0.5119	0.0778	-0.4149	-0.2201	-0.5103	0.0786	-0.4100	-0.2231
0.44	-0.2752	0.1782	-0.1872	-0.1293	-0.2740	0.1810	-0.1830	-0.1306	-0.2730	0.1836	-0.1788	-0.1320
0.50	-0.0305	0.2632	0.0484	-0.0501	-0.0297	0.2676	0.0521	-0.0499	-0.0290	0.2719	0.0557	-0.0500
0.56	0.2195	0.3312	0.2870	0.0199	0.2202	0.3370	0.2902	0.0213	0.2206	0.3427	0.2933	0.0227
0.62	0.4735	0.3819	0.5281	0.0804	0.4742	0.3888	0.5309	0.0830	0.4746	0.3958	0.5336	0.0858
0.68	0.7304	0.4149	0.7715	0.1314	0.7312	0.4227	0.7740	0.1352	0.7316	0.4307	0.7763	0.1392
0.74	0.9890	0.4301	1.0166	0.1727	0.9899	0.4386	1.0188	0.1776	0.9904	0.4474	1.0208	0.1829
0.80	1.2479	0.4273	1.2632	0.2044	1.2490	0.4362	1.2652	0.2102	1.2497	0.4457	1.2670	0.2167
0.86	1.5061	0.4066	1.5108	0.2262	1.5073	0.4157	1.5126	0.2330	1.5082	0.4256	1.5142	0.2405
0.91	1.7196	0.3757	1.7177	0.2370	1.7211	0.3848	1.7194	0.2444	1.7221	0.3948	1.7208	0.2528
0.95	1.8890	0.3421	1.8834	0.2406	1.8905	0.3510	1.8850	0.2486	1.8916	0.3610	1.8863	0.2576
0.98	2.0148	0.3118	2.0076	0.2405	2.0164	0.3205	2.0092	0.2488	2.0176	0.3304	2.0105	0.2583
1.00	2.0981	0.2891	2.0905	0.2390	2.0997	0.2976	2.0920	0.2475	2.1009	0.3074	2.0933	0.2573
L.E. CIRCLE CENTER	(Cm.)		-1.8762	-0.8198			-1.8671	-0.8315			-1.8578	-0.8438
T.E. CIRCLE CENTER	(Cm.)		2.0911	0.2646			2.0926	0.2731			2.0938	0.2829

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 13 FOR XCUT OF 18.1250 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 14 FOR XCUT OF 17.5500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 15 FOR XCUT OF 16.9750 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.8792	-0.8210	-1.8251	-0.8999	-1.8693	-0.8375	-1.8121	-0.9188	-1.8580	-0.8576	-1.7975	-0.9411
0.02	-1.8131	-0.7653	-1.7520	-0.8612	-1.8038	-0.7810	-1.7395	-0.8793	-1.7933	-0.8001	-1.7255	-0.9006
0.05	-1.7126	-0.6834	-1.6420	-0.8038	-1.7042	-0.6979	-1.6302	-0.8208	-1.6948	-0.7155	-1.6171	-0.8406
0.09	-1.5761	-0.5773	-1.4947	-0.7286	-1.5688	-0.5902	-1.4838	-0.7439	-1.5608	-0.6058	-1.4718	-0.7617
0.14	-1.4016	-0.4497	-1.3095	-0.6365	-1.3956	-0.4606	-1.2997	-0.6499	-1.3892	-0.4736	-1.2890	-0.6651
0.20	-1.1866	-0.3043	-1.0857	-0.5290	-1.1821	-0.3126	-1.0772	-0.5400	-1.1775	-0.3225	-1.0681	-0.5523
0.26	-0.9660	-0.1676	-0.8604	-0.4248	-0.9628	-0.1733	-0.8530	-0.4334	-0.9597	-0.1801	-0.8453	-0.4428
0.32	-0.7399	-0.0398	-0.6334	-0.3239	-0.7380	-0.0428	-0.6272	-0.3301	-0.7363	-0.0464	-0.6209	-0.3368
0.38	-0.5090	0.0789	-0.4050	-0.2265	-0.5081	0.0786	-0.3999	-0.2303	-0.5076	0.0781	-0.3948	-0.2342
0.44	-0.2723	0.1860	-0.1746	-0.1337	-0.2723	0.1883	-0.1705	-0.1352	-0.2728	0.1907	-0.1665	-0.1365
0.50	-0.0288	0.2761	0.0592	-0.0499	-0.0294	0.2809	0.0625	-0.0492	-0.0304	0.2860	0.0656	-0.0481
0.56	0.2206	0.3486	0.2963	0.0244	0.2196	0.3556	0.2988	0.0272	0.2183	0.3631	0.3011	0.0306
0.62	0.4744	0.4032	0.5361	0.0891	0.4734	0.4122	0.5381	0.0939	0.4719	0.4217	0.5398	0.0993
0.68	0.7315	0.4395	0.7783	0.1440	0.7305	0.4501	0.7798	0.1507	0.7292	0.4614	0.7811	0.1580
0.74	0.9904	0.4573	1.0225	0.1891	0.9896	0.4693	1.0237	0.1976	0.9886	0.4819	1.0246	0.2065
0.80	1.2499	0.4564	1.2684	0.2243	1.2494	0.4694	1.2693	0.2343	1.2487	0.4829	1.2699	0.2446
0.86	1.5086	0.4368	1.5154	0.2494	1.5085	0.4505	1.5161	0.2607	1.5081	0.4644	1.5166	0.2723
0.91	1.7227	0.4063	1.7219	0.2627	1.7228	0.4202	1.7225	0.2749	1.7227	0.4342	1.7229	0.2873
0.95	1.8923	0.3726	1.8873	0.2682	1.8926	0.3864	1.8878	0.2811	1.8927	0.4003	1.8882	0.2940
0.98	2.0183	0.3419	2.0114	0.2694	2.0188	0.3556	2.0119	0.2827	2.0190	0.3692	2.0122	0.2959
1.00	2.1017	0.3189	2.0941	0.2688	2.1022	0.3325	2.0946	0.2824	2.1025	0.3459	2.0949	0.2957
L.E. CIRCLE CENTER	(Cm.)		-1.8478	-0.8575			-1.8362	-0.8750			1.8232	0.8960
T.E. CIRCLE CENTER	(Cm.)		2.0946	0.2944			2.0950	0.3080			2.0952	0.3213

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** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT. OF SURF.	SECTION 16 FOR XCUT OF 16.4000 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 17 FOR XCUT OF 15.8250 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 18 FOR XCUT OF 15.2500 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.8471	-0.8766	-1.7832	-0.9623	-1.8361	-0.8959	-1.7686	-0.9837	-1.8240	-0.9178	-1.7529	-1.0075
0.02	-1.7832	-0.8181	-1.7118	-0.9208	-1.7729	-0.8365	-1.6978	-0.9412	-1.7616	-0.8573	-1.6927	-0.9640
0.05	-1.6858	-0.7320	-1.6043	-0.8592	-1.6766	-0.7489	-1.5912	-0.8782	-1.6666	-0.7681	-1.5771	-0.8993
0.09	-1.5531	-0.6202	-1.4602	-0.7784	-1.5453	-0.6352	-1.4483	-0.7954	-1.5369	-0.6522	-1.4355	-0.8143
0.14	-1.3831	-0.4855	-1.2788	-0.6794	-1.3769	-0.4980	-1.2683	-0.6940	-1.3703	-0.5123	-1.2571	-0.7103
0.20	-1.1731	-0.3315	-1.0593	-0.5637	-1.1687	-0.3409	-1.0504	-0.5755	-1.1641	-0.3518	-1.0410	-0.5886
0.26	-0.9568	-0.1860	-0.8380	-0.4515	-0.9540	-0.1923	-0.8306	-0.4605	-0.9513	-0.1998	-0.8229	-0.4705
0.32	-0.7347	-0.0494	-0.6149	-0.3428	-0.7334	-0.0527	-0.6088	-0.3491	-0.7322	-0.0567	-0.6027	-0.3560
0.38	-0.5072	0.0780	-0.3899	-0.2377	-0.5070	0.0778	-0.3852	-0.2413	-0.5073	0.0772	-0.3805	-0.2453
0.44	-0.2733	0.1934	-0.1627	-0.1377	-0.2741	0.1962	-0.1591	-0.1387	-0.2754	0.1989	-0.1556	-0.1397
0.50	-0.0315	0.2912	0.0685	-0.0470	-0.0329	0.2966	0.0712	-0.0456	-0.0349	0.3023	0.0735	-0.0440
0.56	0.2169	0.3706	0.3033	0.0338	0.2152	0.3784	0.3052	0.0374	0.2129	0.3867	0.3068	0.0415
0.62	0.4705	0.4311	0.5414	0.1045	0.4688	0.4409	0.5427	0.1101	0.4665	0.4515	0.5436	0.1164
0.68	0.7279	0.4723	0.7822	0.1649	0.7263	0.4838	0.7830	0.1723	0.7242	0.4962	0.7835	0.1806
0.74	0.9875	0.4940	1.0254	0.2149	0.9863	0.5066	1.0259	0.2238	0.9846	0.5203	1.0260	0.2337
0.80	1.2480	0.4958	1.2705	0.2543	1.2471	0.5092	1.2708	0.2645	1.2460	0.5236	1.2707	0.2757
0.86	1.5078	0.4777	1.5170	0.2831	1.5073	0.4913	1.5171	0.2942	1.5067	0.5059	1.5170	0.3063
0.91	1.7227	0.4474	1.7232	0.2988	1.7225	0.4608	1.7233	0.3105	1.7222	0.4751	1.7231	0.3230
0.95	1.8929	0.4132	1.8884	0.3059	1.8929	0.4263	1.8885	0.3180	1.8929	0.4398	1.8883	0.3305
0.98	2.0192	0.3819	2.0124	0.3081	2.0194	0.3944	2.0125	0.3203	2.0194	0.4073	2.0123	0.3327
1.00	2.1028	0.3582	2.0951	0.3080	2.1029	0.3704	2.0951	0.3202	2.1030	0.3828	2.0950	0.3326

L.E. CIRCLE CENTER (Cm.)	-1.8105	-0.9159	-1.7975	-0.9361	-1.7835	-0.9588
T.E. CIRCLE CENTER (Cm.)	2.0954	0.3337	2.0954	0.3459	2.0953	0.3583

1

** BLADE SECTION COORDINATES OF STATOR NO. 1 FOLLOWING ROTOR NO. 1 IN THE TURBOMACHINE ORIENTATION **

FRACT OF SURF	SECTION 19 FOR XCUT OF 14.6750 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)	SECTION 20 FOR XCUT OF 25.1451 Cm. SUCTION SURFACE Z (Cm.)	Y (Cm.)	PRESSURE SURFACE Z (Cm.)	Y (Cm.)
0.00	-1.8102	-0.9439	-1.7349	-1.0353	-1.9620	-0.7660	-1.9348	-0.8086
0.02	-1.7489	-0.8822	-1.6657	-0.9905	-1.8937	-0.7120	-1.8597	-0.7715
0.05	-1.6553	-0.7912	-1.5613	-0.9240	-1.7896	-0.6328	-1.7467	-0.7166
0.09	-1.5275	-0.6728	-1.4212	-0.8365	-1.6482	-0.5309	-1.5953	-0.6450
0.14	-1.3631	-0.5296	-1.2447	-0.7294	-1.4674	-0.4094	-1.4048	-0.5580
0.20	-1.1593	-0.3652	-1.0308	-0.6040	-1.2447	-0.2725	-1.1746	-0.4575
0.26	-0.9486	-0.2093	-0.8146	-0.4822	-1.0162	-0.1455	-0.9426	-0.3610
0.32	-0.7314	-0.0621	-0.5962	-0.3641	-0.7823	-0.0287	-0.7090	-0.2687
0.38	-0.5081	0.0759	-0.3757	-0.2498	-0.5435	0.0776	-0.4737	-0.1806
0.44	-0.2775	0.2014	-0.1524	-0.1408	-0.2996	0.1715	-0.2365	-0.0981
0.50	-0.0377	0.3084	0.0756	-0.0419	-0.0495	0.2473	0.0044	-0.0269
0.56	0.2098	0.3959	0.3079	0.0465	0.2056	0.3046	0.2485	0.0324
0.62	0.4634	0.4633	0.5440	0.1240	0.4641	0.3429	0.4952	0.0796
0.68	0.7215	0.5101	0.7834	0.1903	0.7248	0.3620	0.7439	0.1145
0.74	0.9824	0.5356	1.0257	0.2452	0.9861	0.3619	0.9941	0.1371
0.80	1.2445	0.5397	1.2703	0.2884	1.2468	0.3425	1.2451	0.1473
0.86	1.5058	0.5220	1.5166	0.3198	1.5053	0.3040	1.4962	0.1452
0.91	1.7218	0.4905	1.7227	0.3367	1.7181	0.2574	1.7053	0.1339
0.95	1.8927	0.4544	1.8880	0.3440	1.8860	0.2108	1.8720	0.1187
0.98	2.0194	0.4210	2.0120	0.3460	2.0103	0.1705	1.9968	0.1037
1.00	2.1030	0.3957	2.0947	0.3455	2.0924	0.1410	2.0797	0.0920
L.E. CIRCLE CENTER (Cm.)			-1.7676	-0.9855			-1.9461	-0.7859
T.E. CIRCLE CENTER (Cm.)			2.0951	0.3712			2.0834	0.1172

APPENDIX C. TEST RIG

This appendix contains information pertaining to the transonic axial compressor test rig located at the NPS TPL. Included is the general procedure involved in operating the test rig, and its disassembly and reassembly. This information is provided to fill the void that currently exists in the documentation associated with maintenance and operation of the test rig.

A. OPERATING PROCEDURE

A photograph of the control panel, from which the operation of the test rig is controlled and monitored, is located in Figure 23. The panel is used to control the supply of air from the laboratory's 12 stage compressor to the test-rig drive turbine, to relieve the axial load on the drive shaft bearings by porting low pressure air to a balance piston inside the compressor hub, and to remotely operate the hydraulic throttle located in the compressor-intake housing. It is also used to monitor the operating temperatures of the drive-shaft bearings, the RPM, and levels of vibrations. The following is a description of the operating procedure.

1. The technician starts and warms up the laboratory air-supply compressor (1 hour), with the bypass (dump) valves in the open position.
2. Turn on the control-panel activation switch (located beneath the control-panel counter-top).
3. Ensure that air is being supplied to the balance piston, and bearing oil-mist cooling lines. This air is supplied through the shop air lines, by the Elliot compressor.
4. Set the oil-mist cooling, air-oil regulators, to 35 psi, and 12 drops of oil per minute (count the number of drips over a three minute interval and average).
5. Check that the bearing temperature readings are indicating test-cell ambient values (not wandering).

6. Close supply-air dump valves (2 ea.),until a two-to-one pressure ratio across the laboratory air supply compressor is indicated (on gauge to the right of control panel), and the noise level in the control room is acceptable (some combinations of valve settings are noisy).
7. Open air supply valve and close dump valves partially until desired RPM is indicated, while maintaining the two-to-one pressure ratio across the air supply compressor.
8. As the RPM increases, the air supplied to the balance piston must be increased to compensate for the axial load on the bearings. If the value displayed on the analogue readout is maintained at the level indicated before start-up (with no air supplied to the balance piston), the axial load produced by the spinning rotor will be negated by the pressure on the balance piston. This will result in approximately zero axial load on the high speed bearings.
9. Set throttle valve as required, and correct air-supply valve to maintain RPM.

During operation of the test rig, RPM, bearing temperature, balance piston, and vibration indications must be monitored continuously. Additionally, periodic checks of the oil-mist regulators is recommended.

B. DISASSEMBLY AND REASSEMBLY

The disassembly and reassembly performed in association with this report was documented on video tape. This tape will be maintained with the records of the test rig for guidance in future overhaul efforts. A few notes, however, concerning the disassembly and reassembly of the machine should be emphasized.

Disassembly

- The removal of the inlet nozzle bell from the hub housing is tricky. Extreme care must be taken to prevent the shroud (attached to, and removed with, the nozzle bell), from coming into contact with the rotor blade tips. To remove the nozzle bell and shroud assembly without incident, pull out the positioning pins, and un-screw the bolts securing the assembly to its support structure. Then attach the test-cell overhead crane to the eye bolt on the top of the nozzle and raise the crane until there is a slight tension on the chain. Attach a winch to the nozzle-inlet face, and the piping from the inlet housing (outside the test cell), and gently pull it axially away from the hub housing. If the winch cables are evenly distributed around the nozzle face the assembly should slide along the channels fastened to the nozzle-bell support structure that ensure clearance of the rotor blade tips. The overhead crane will prevent the assembly from dropping as it clears the edge of the nozzle base.

Reassembly

- Ensure that markings on splines are located during disassembly and aligned during reassembly. These markings line up the high speed rotational components as they were when the machine was originally balanced.
- The pre-load on the high speed bearings is defined as "light". A mere 2-3 in.-lb. torque, on the rotor mounting bolt, is all that is desired to keep the bearings, rotor and rotor shaft in place.
- Perform a new calibration of the torque balance each time the machine is reassembled.
- Check bearing oil-mist cooling lines, bearing temperatures, and internal instrumentation lines for proper operation/indications prior to reassembling.

C. INSTRUMENTATION

The test runs and overhaul of the test rig, as described in this report, have been primarily driven by the desire to return the machine to routine operation. The myriad of instrumentation, that was added in a piece-meal fashion over the fifteen years of operation of the rig, is in need of overhaul. Currently the data-acquisition system at the TPL is in transition. The Hewlett-Packard Basic workstation and programs that have been used for data acquisition are being augmented and possibly replaced with a PC data acquisition controller using Labview™. A VXI-Bus mainframe has been purchased, and obsolete scanners are to be replaced. All instrumentation lines from the test-cell to the data acquisition area must yet be verified or replaced before performance mapping of the new stage can begin.

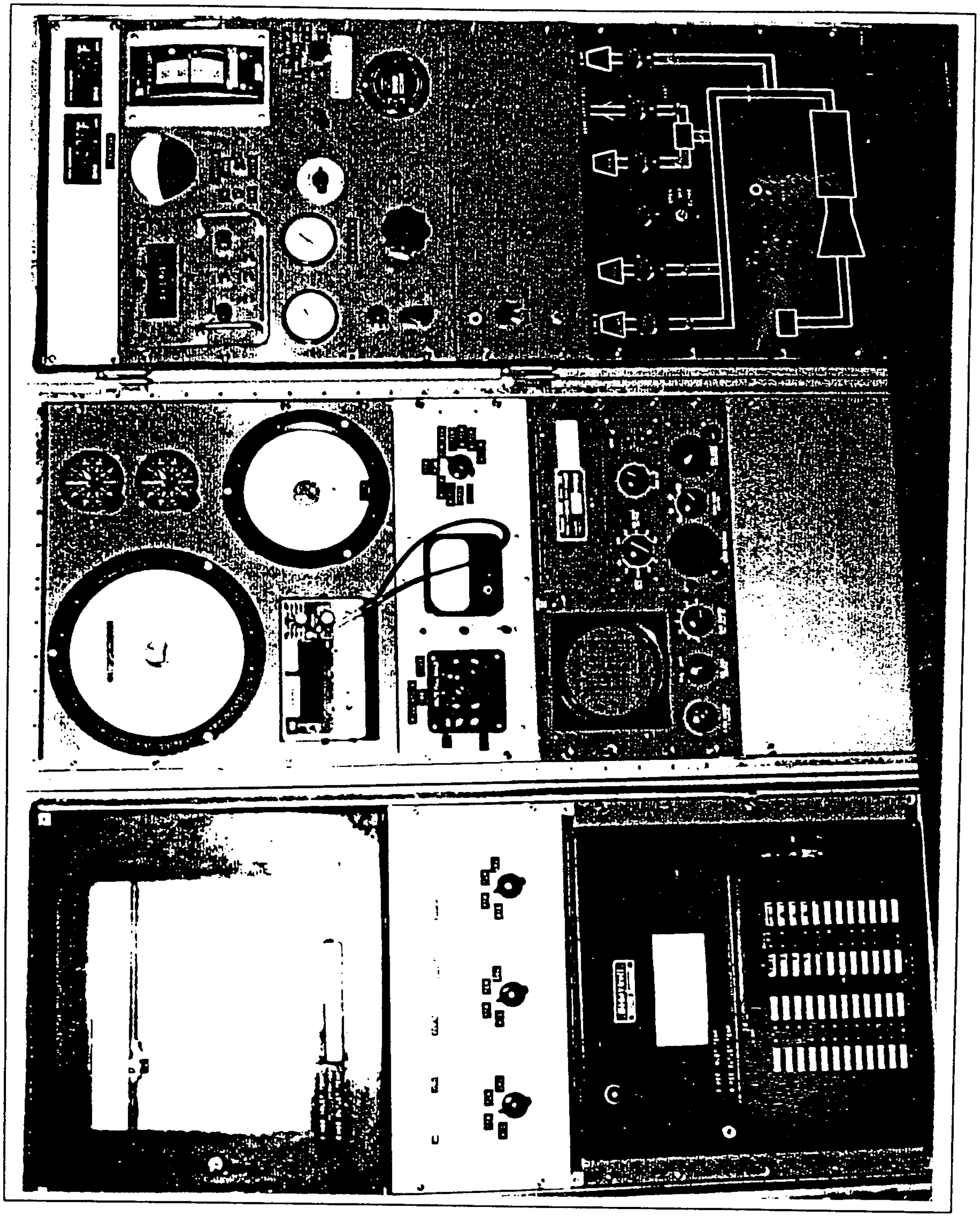

Figure 23. Transonic Compressor Test Rig Control Panel.

LIST OF REFERENCES

1. Paige, G. C., Measurement of Case Wall Pressure Signatures in a Transonic Compressor Using Real-Time Digital Instrumentation, M.S. Thesis, Naval Post Graduate School, June 1976.

2. West, J.C., Digital Programmable Timing Device for Fast Response Instrumentation in Rotating Machines, , M.S. Thesis, Naval Postgraduate School, December 1976.

3. Simmons, J. M., Data Acquisition and Analysis Techniques for Measuremen of Unsteady Wall Pressures in a Transonic Compressor, M.S. Thesis, Naval Postgraduate School, July 1977.

4. Dodge, F.J., Development of a Temperature-Pneumatic Probe and Application at the Rotor Exit in a Transonic Compressor, M.S. Thesis, Naval Postgraduate School, June 1976.

5. Hawkins, W.R., Determination of the Blade-Element Performance of a Small Transonic Rotor, M.S. Thesis, Naval Postgraduate School, December 1976.

6. Erwin, J. R., A Review of the Design of the NPS/TPL Transonic Compressor, Contractor Report NPS67-83-004CR, Naval Postgraduate School, Monterey, California, March 1983.

7. Neuhoff, F., Shreeve, R.P., and, Fottner, L., Evaluation of the Blade-to-Blade Flow From a High Speed Compressor Rotor, ASME Paper 86-GT-117, Presented at the International Gas Turbine Conference and Exhibit, Dusseldorf, West Germany, June 8-12, 1986.

8. Sanger, N.L., Design of a Low Aspect Ratio Transonic Compressor Stage Using CFD Techniques, ASME Paper No. 94-GT-236, Presented at the International Gas Turbine and Aeroengine Congress and Exposition, The Hague, The Netherlands, June 13-16, 1994.

9. Crouse, J.E., and Gorrell, W.T., Computer Program for Aerodynamic and Blading Design of Multistage Axial-Flow Compressors, NASA Technical Paper 1946, NASA Lewis Research Center, Cleveland, Ohio, December 1981.

10. Reid, W.D., AXIDES Code Input and Output Files, Turbopropulsion Laboratory Technical Note, TPL-TN-95- 01, Naval Postgraduate School, Monterey, California, September 1995.

11. Denton, J.D., An Improved Time-Marching Method for Turbomachinery Flow Calculation, ASME Paper 82-GT-239, Presented at the 27th International Gas Turbine Conference and Exhibit, London, England, April 18-22, 1982.

12. McNally, W.D., FORTRAN Program for Calculating Compressible Laminar and Turbulent Boundary Layers in Arbitrary Pressure Gradients, NASA TN D-5861, NASA Lewis Research Center, Cleveland, Ohio, 1970.

13. Denton, J.D., The Use of a Distributed Body Force to Simulate Viscous Effects in 3D Calculations, ASME Paper 86-GT-144, Presented at the International Gas Turbine Conference and Exhibit, Dusseldorf, West Germany, June 8-12, 1986.

14. Katsanis, T., FORTRAN Program for Calculating Transonic Velocities on a Blade-to-Blade Stream Surface of a Turbomachine, NASA TN D-5427, NASA Lewis Research Center, Cleveland, Ohio, 1969.

15. Katsanis, T., and, McNally, W.D., Revised FORTRAN Program for Calculating Velocities and Streamlines on the Hub-Shroud Midchannel Stream Surface of an Axial-, Radial-, or Mixed-Flow Turbomachine or Annular Duct, NASA TN D-8430, NASA Lewis Research Center, Cleveland, Ohio, March 1977.

16. National Aeronautics and Space Administration Report No. N65-23345, Aerodynamic Design of Axial-Flow Compressors, NASA SP-36, Washington, D.C., 1965

17. Shreeve, R.P., Report on the Testing of a Hybrid (Radial-to-Axial) Compressor, Report No. NPS-57Sf73112A, Naval Postgraduate School, Monterey, California, November 1973.

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